

#### 4. POLLUTANT STATISTICS AND RELATIONSHIPS BETWEEN POLLUTANT AND METEOROLOGICAL PARAMETERS DURING THE VCOT STUDY

In this section we describe the spatial and temporal distribution of ozone daily maxima during the VCOT study. In addition, data summaries, plots, and correlations are presented which show the relationships between these daily maximum ozone concentrations and various meteorological parameters. These relationships were used to assess the meteorological conditions under which high Ventura County ozone concentrations and Los Angeles to Ventura County ozone transport occurred. Most of the data used to prepare the plots and summaries in this section are included in tabular form in Appendix A.

##### 4.1 VENTURA COUNTY OZONE CONCENTRATION STATISTICS DURING THE STUDY PERIOD

The VCOT study was designed to look for the effects of Los Angeles to Ventura County pollutant transport on Ventura County ozone concentrations. The September time period was chosen since transport conditions are likely during that month and since exceedances of the ozone standard in the coastal regions typically occur during that time. The study was also designed to examine the effects of elevated ozone layers on surface concentrations. Even though the meteorology of the study period had more than usual coastal cloudiness and storm activity, we were fortunate in that the period was also a time of high ozone concentrations in Ventura County with many "transport" days and many days with elevated ozone layers over Ventura County.

For the VCOT study period, a set of surface ozone data was obtained which included data from six sites from the VCAPCD network, a site operated by CARB, plus elevated stations at Rocketdyne and Laguna Peak. These sites are shown in Figure 1-1. The number of days and hours when exceedances of the California and federal ozone standards occurred at these sites during the study period are listed in Table 4-1. The frequencies of occurrence of ozone maxima for each site are plotted in Figure 4-1. It is apparent that the highest number of hours of ozone exceedances occurred at those sites nearest to the Los Angeles County boundary. It is also evident that elevated sites (Rocketdyne, Laguna Peak, and Ojai) even near the coast, experienced substantial periods of high ozone.

As indicated in Section 3 and further discussed in Section 4-2, the 1000 PST Pt. Mugu winds at about 3000' msl are a reasonable indicator of the potential for transport between Los Angeles and Ventura County. Using wind directions between  $045^{\circ}$  and  $180^{\circ}$  as the criteria for transport, 21 of the 26 days that the mid-morning Pt. Mugu soundings were made during the study period were potential transport days.

The median times for those hours during the study period when the ozone concentration at each site exceeded 12 pphm are shown on the map in Figure 4-2. From Figure 4-2 we can see that the periods of high ozone occurred in midday in the eastern part of the county; yet in the coastal regions, the high ozone concentrations occurred in mid to late afternoon. These times of high ozone occurrence are consistent with the large number of days of potential transport from Los Angeles to Ventura County which

Table 4-1. Ozone Levels for September 1 - October 6, 1983

SITE	# HOURS		# DAYS		PEAK CONCENTRATION
	>10 pphm*	>12 pphm**	>10 pphm	>12 pphm	
La Conchita (CARB)	0	0	0	0	10
Ventura (VCAPCD)	14	6	4	3	15
El Rio (VCAPCD)	10	6	3	2	14
Thousand Oaks (VCAPCD)	31	8	10	4	18
Ojai (VCAPCD)	31	10	9	3	15
Simi (VCAPCD)	72	28	16	11	23
Piru (VCAPCD)	49	12	14	6	17
Rocketdyne	106	64	18	15	28
Laguna Peak	38	20	10	7	17

\* California Standard

\*\* Federal Standard

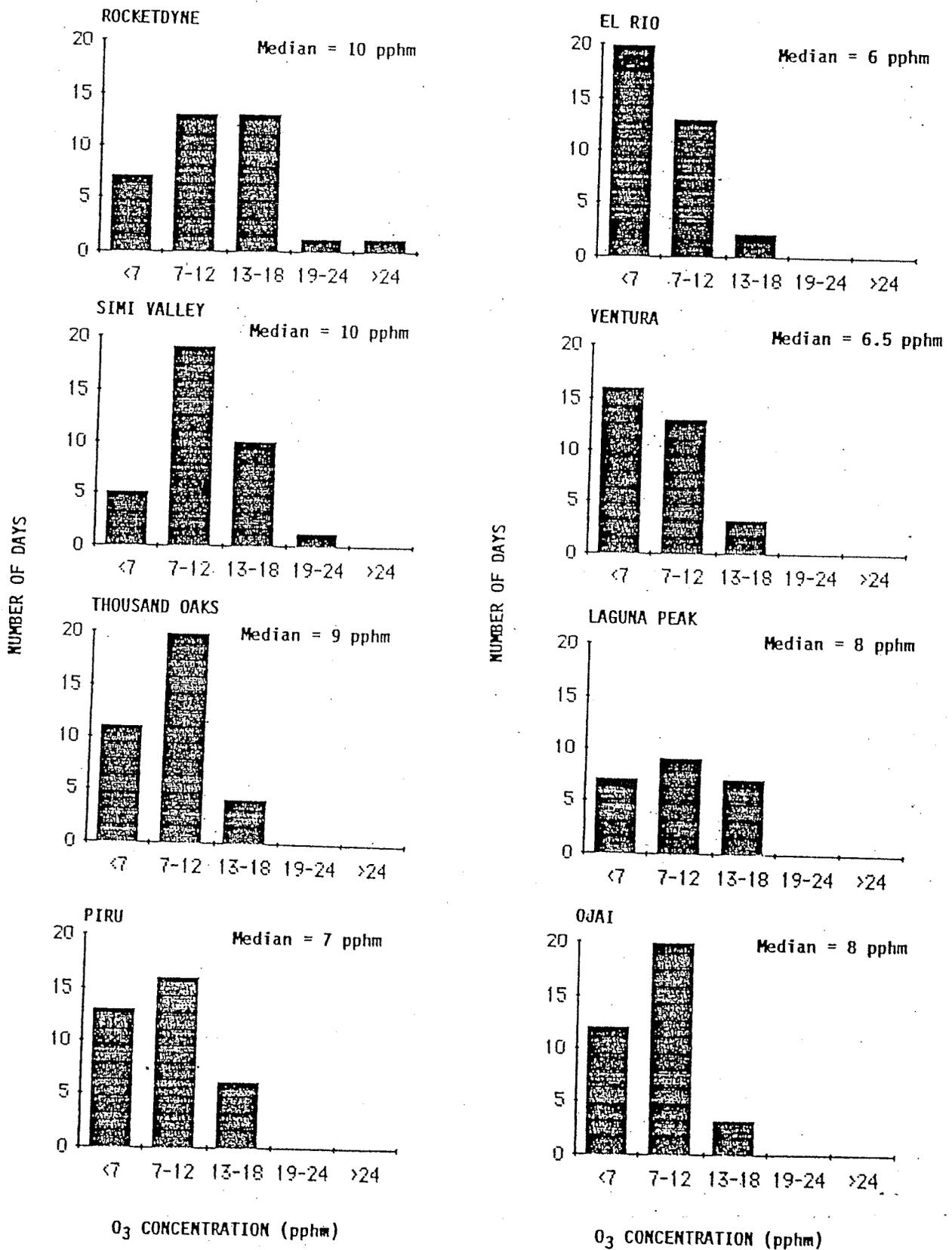


Figure 4-1. Frequency of Occurrence of Ozone Maxima from September 1 - October 6, 1983.

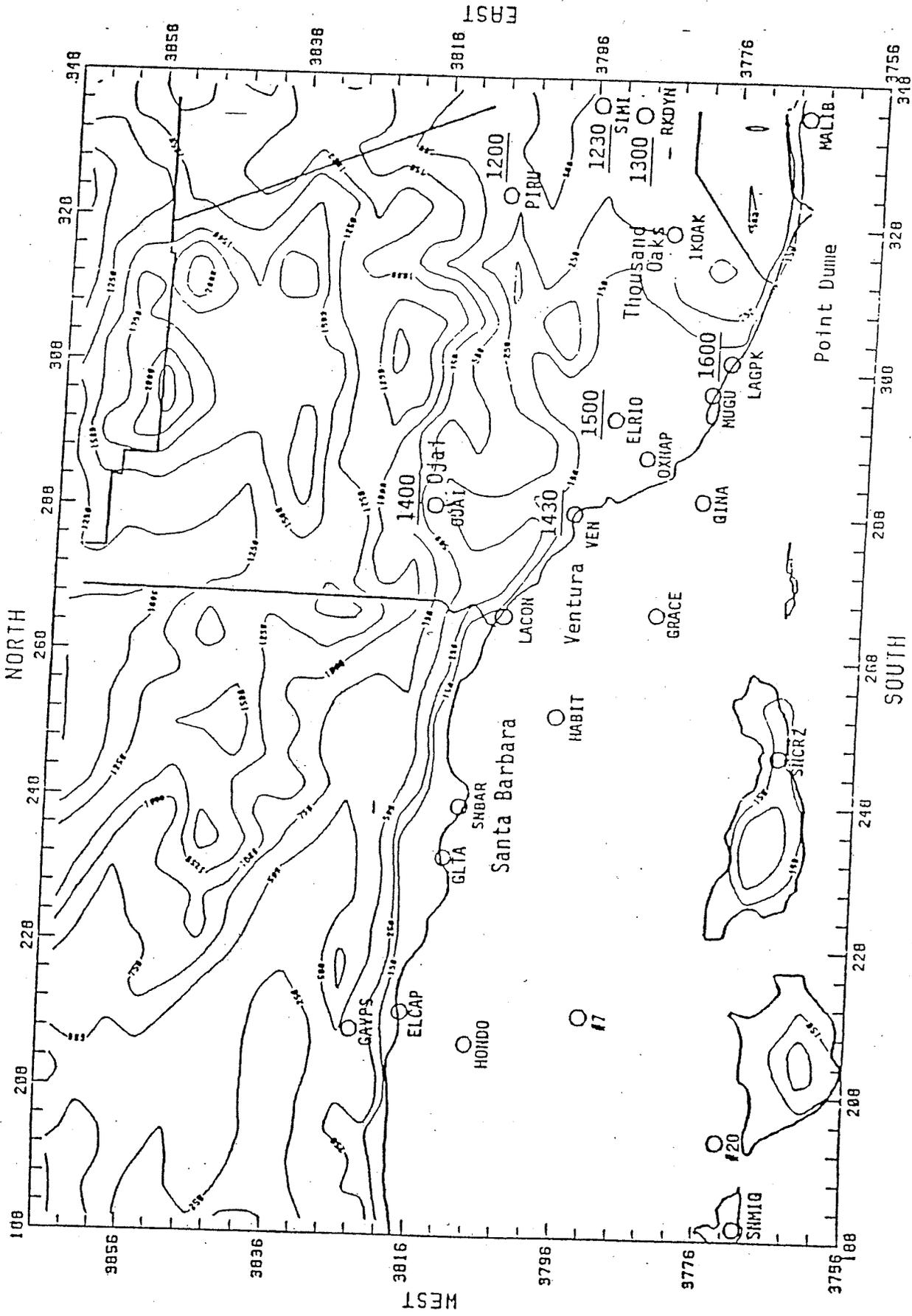


Figure 4-2. Median Times (PST) for Hours Exceeding 12 pphm Ozone.

occurred during the study period (e.g. Figure 3-3 for September 11, 1983). Transport along the inland route results in midday peak concentrations in eastern Ventura County while transport along the coastal route takes longer and results in later ozone peaks in the coastal regions.

The ozone concentrations measured aloft during the three daily aircraft soundings are summarized in Table 4-2. All of the routine sounding locations frequently had elevated layers of ozone, and the median altitude of peak ozone concentrations was well above the surface at all locations. Days when surface ozone concentrations in Ventura County exceeded 12 pphm typically had higher ozone concentrations aloft than non-exceedance days, and elevated layers were measured on all exceedance days. (See Table 3-20).

#### 4.2 RELATIONSHIPS BETWEEN VARIOUS POLLUTANT AND METEOROLOGICAL PARAMETERS

The high ozone days ( $> 12$  pphm) in Ventura County had several noticeable characteristics. As seen in Figure 1-3, the 850 mb temperature was typically higher than  $20^{\circ}\text{C}$ , indicating a regional high pressure condition. For the study period, the correlation between the Ventura County daily maximum hourly ozone concentration and the morning 850 mb temperature at Vandenberg AFB was 0.80. A scatterplot of the ozone and 850 mb temperature data is presented in Figure 4-3. The maximum ozone concentrations in Ventura County were also well correlated with the maximum concentrations at the four nearest Los Angeles County stations, again indicating a regional situation. Figure 4-4 is a scatterplot of the maximum hourly ozone concentration in Ventura County plotted against the maximum concentration at Lennox, West Los Angeles, Reseda, or Burbank. The correlation is 0.78 between the Ventura County and Los Angeles County sites. The correlation between the same Ventura County data and the maximum ozone at the four upwind sites for the previous day is still 0.76, as shown in Figure 4-5.

Another characteristic of high ozone days in Ventura County was that ozone layers aloft typically existed on these days along with an easterly flow component aloft. In addition, the mixing was confined below 3000' msl and the boundary layer background ozone concentrations were relatively high, typically from 5 - 9 pphm. These conditions are indicated in Figures 4-6 - 4-9 which are scatterplots of maximum surface ozone in the VCOI data set plotted against ozone in upper layers, wind direction aloft, mixing height, and background ozone aloft in the region (typically at approximately 3000' msl). The upper air data for Figures 4-6 through 4-9 were obtained from the aircraft soundings and from the Pt. Mugu rawinsondes.

The analyses above indicate that high ozone concentrations in Ventura County during the study period were associated with high pressure conditions and with regional pollution episodes which also encompassed Los Angeles County. The association of high ozone in Ventura County with an easterly flow component aloft (Figure 4-7) indicates that some of the high ozone in Ventura County was likely to be due to transport from Los Angeles County. The association with ozone in elevated layers (Figure 4-6) is also important to note. During the study, the maximum ozone concentrations measured on exceedance days occurred at an elevated site (Laguna Peak or Rocketdyne) on all days but one. As noted in Section 3, these layers often have their origins to the east and southeast and are available to be mixed to the surface. To further assess the transport issue, we examined the surface and elevated wind fields during the study period.

Table 4-2. Summary of Ozone Soundings Median Peak Concentrations (pphm) and Heights (m msl).

LOCATION	TIME (PST)		
	05	10	15
#1* Camarillo	6 pphm 725 m msl	12 500	14 550
#2 (3 mi. S of Laguna Peak)	7 675	11 625	13 400
#3 (13 mi. S of Laguna Peak)	7 400	10 425	11 400
#7 (Westlake)	8 800	13 625	11 800
#9 (Simi)	8 825	15 700	15 800

\* See Figure 1-2 for spiral locations

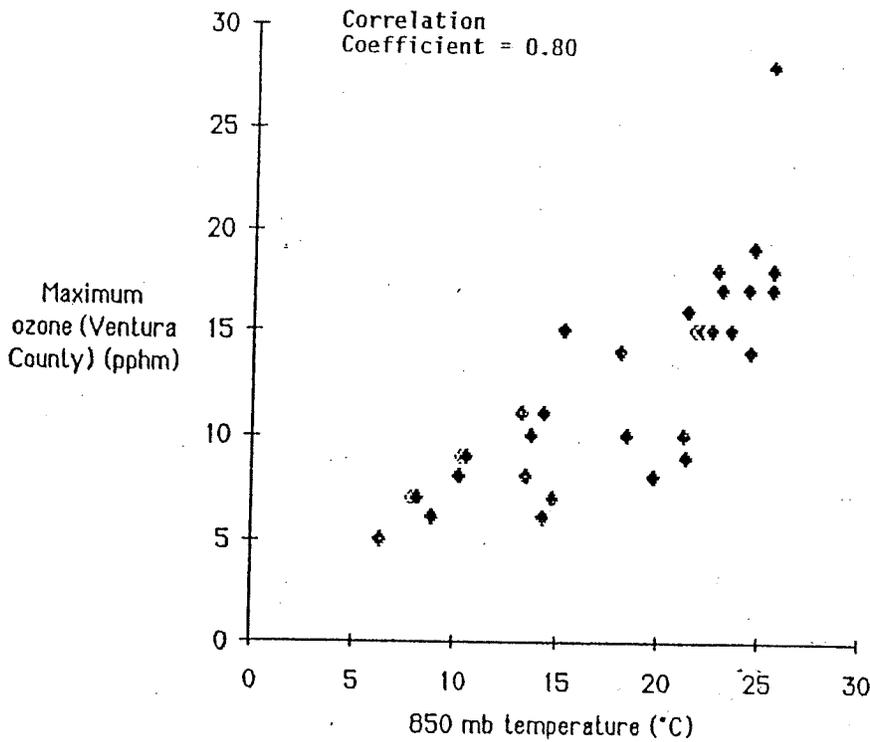


Figure 4-3. Ventura County Maximum Ozone vs. 850 mb Temperature at Vandenberg AFB.

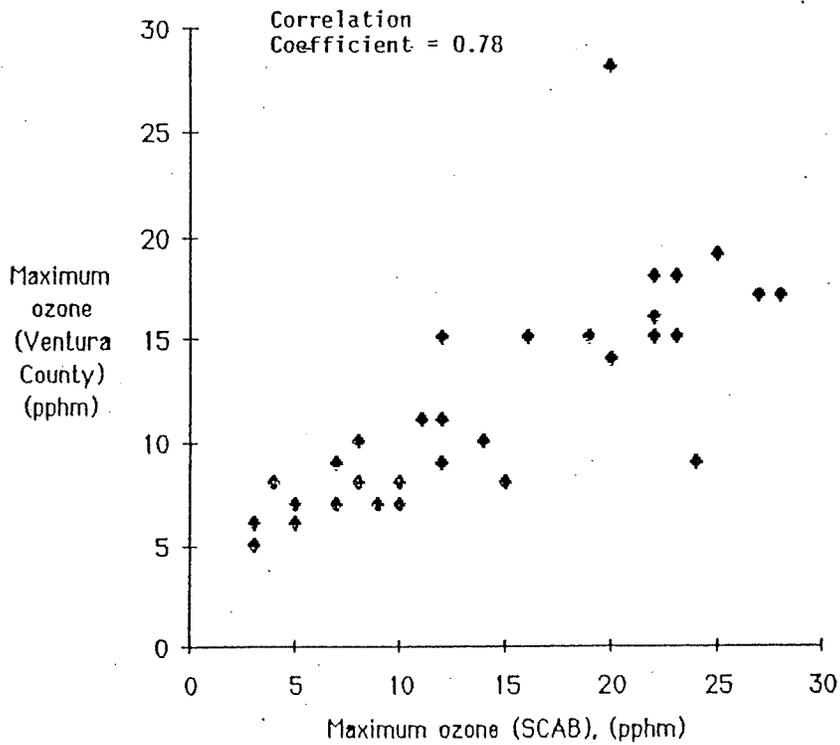


Figure 4-4. Ventura County Maximum Surface Ozone vs. Maximum Ozone at Four Upwind (SCAB) Sites During VCOT Study. (Ventura County sites include Rocketdyne and Laguna Peak.)

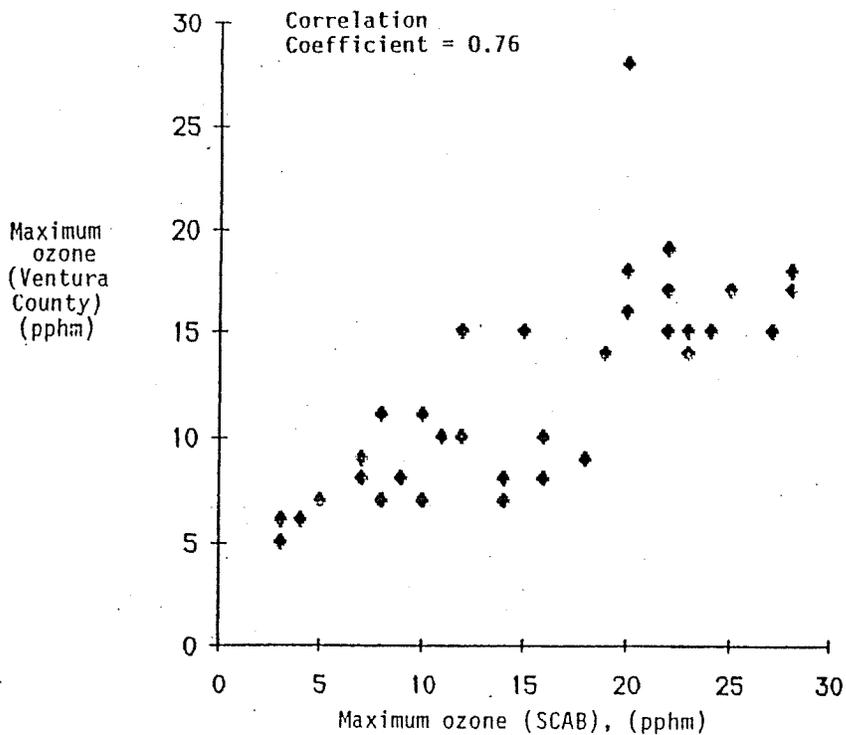


Figure 4-5. Ventura County Maximum Surface Ozone vs. Maximum Ozone from Previous Day at Four Upwind (SCAB) Sites During VCOT Study. (Ventura County sites include Rocketdyne and Lagune Peak.)

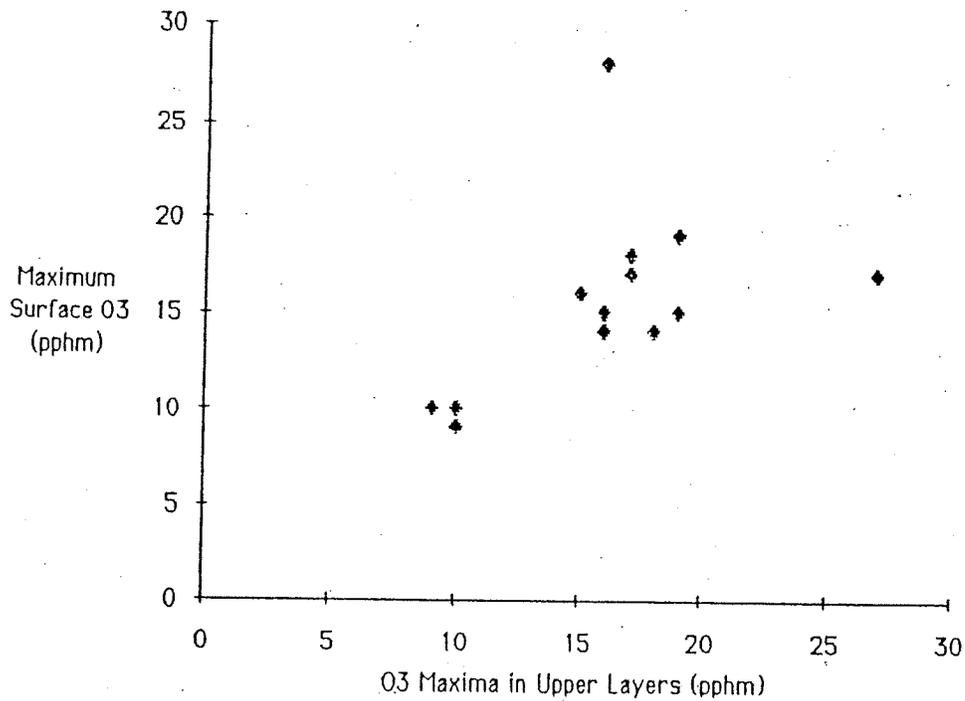


Figure 4-6. Surface O<sub>3</sub> Maxima vs. Maximum concentration in Early Morning or Midday elevated Layers. (September 1 - 20, 1983 data only.)

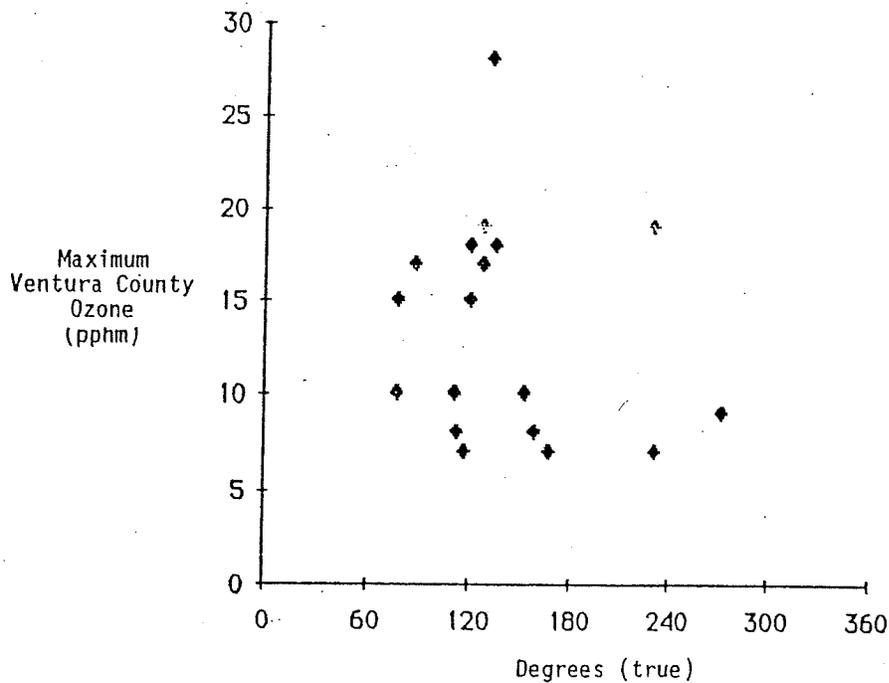


Figure 4-7. Maximum Daily Hourly Average Ozone Concentration vs. Wind Direction at 3000' msl from the Midmorning Pt. Mugu Radiosonde during the VCOT Study.

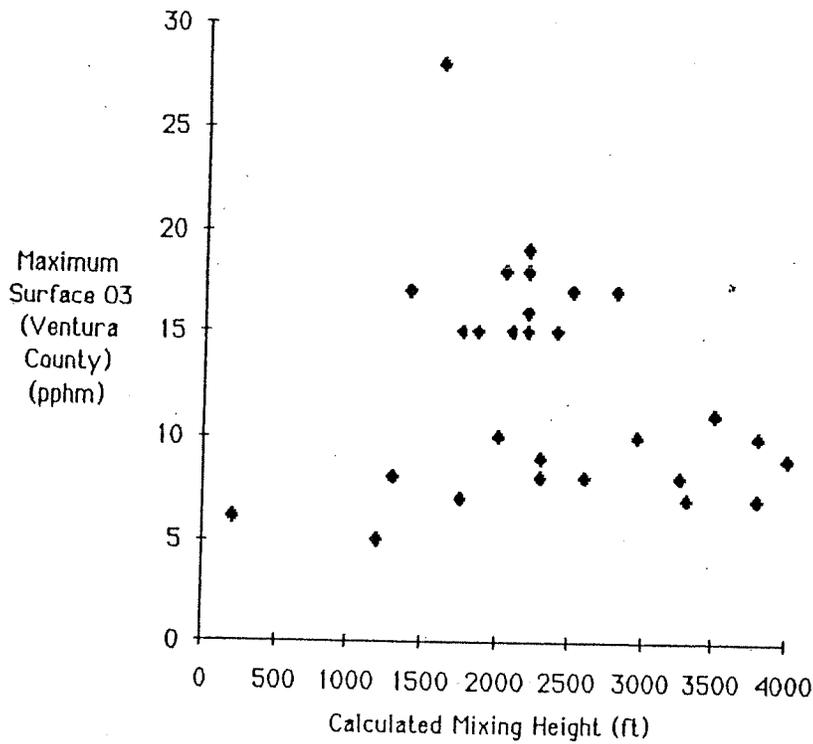


Figure 4-8. Maximum Surface Ozone vs. Maximum Mixing Height. (Calculated from the early morning Point Mugu radiosonde and the maximum surface temperature at Simi.)

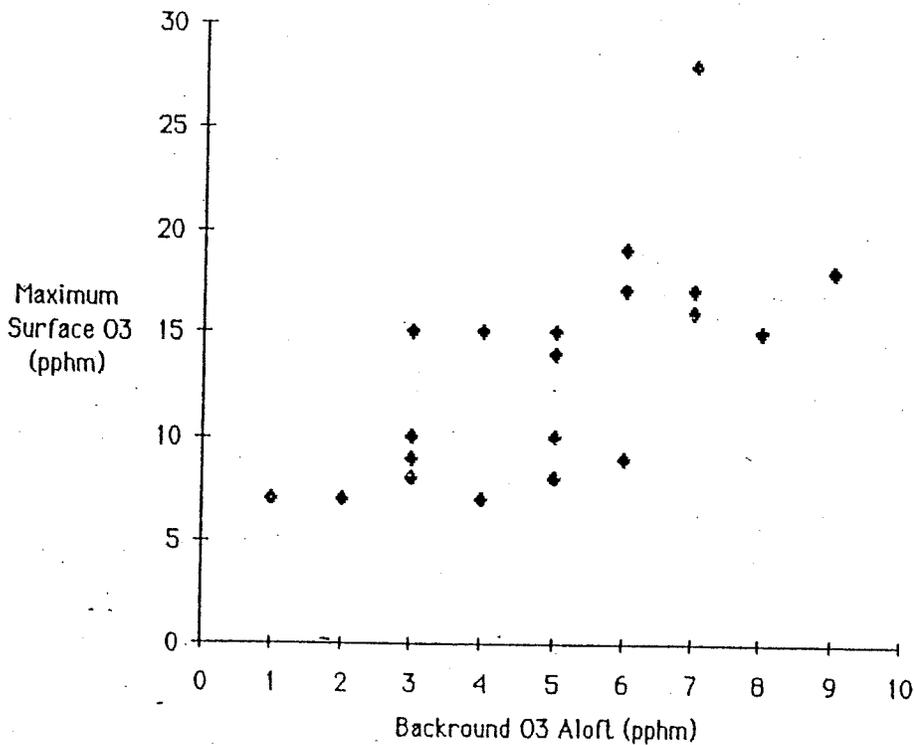


Figure 4-9. Surface Peak Ozone vs. Background Ozone in Ventura County During the VCOT Study. (Background ozone was obtained from the aircraft sounding data at the top of the regional boundary layer (~3000'.))

The prevailing streamlines for the 0600-0800 PST hours during days when maximum ozone concentrations > 12 pphm were observed in Ventura County are shown in Figure 4-10. These streamlines are estimated from the most frequent wind directions and the average speed for those directions. The surface flows over land show a general easterly to southeasterly flow, and the elevated locations show a southeasterly flow. These flows indicate transport from Los Angeles to Ventura County both at the surface and aloft on high ozone days during the study period.

The ozone maxima for exceedance days (>12 pphm) at selected sites for the study period and the corresponding winds aloft at several locations are listed in Table 4-3. On all but one exceedance day, an easterly component was seen aloft in one of the upper air locations. On the one day that was an exception, the Ventura County upper winds were missing and the west Los Angeles upper wind was essentially calm.

To examine the source of the air which arrived at the monitoring sites during periods of high ozone, we calculated back trajectories using surface wind data. For the median times of peak ozone on exceedance days at four sites, back trajectories were calculated using the prevailing wind directions and average wind speeds. These trajectories are shown in Figure 4-11. These prevailing flows are consistent with the transport mechanisms described in Section 3.

The Piru trajectory shows an origin on the coastal plain in the early morning. This trajectory seems to indicate a potential Ventura County source for the ozone seen at Piru, but it does not exclude a transport component. As mentioned in Section 3, the elevated flows can be easterly even when the surface flows are westerly. As the surface air moves inland, the mixing layer deepens, and ozone from elevated layers with origins to the east can be entrained and mixed to the surface.

In summary, during the study, high ozone concentrations in Ventura County were typically associated with the following conditions:

- 850 mb temperatures above  $\sim 20^{\circ}\text{C}$
- background ozone aloft of 5-9 pphm
- layers of high ozone concentration above the surface in early morning or midday
- mixing depths below about 3000'
- an easterly component to the flow aloft

These conditions are typical of the high pressure systems which result in regional stagnation conditions. Although the same conditions would be conducive to a buildup of ozone in Ventura County with or without transport from Los Angeles County, it is apparent that substantial transport occurred during the study period. Since the study was designed to look for transport, it is likely that other parts of the summer may exhibit less transport, and less of an effect of transport on Ventura County ozone concentrations. These issues are examined further in Sections 5 and 6.

To establish the frequency of potential transport impact during periods other than the study period, it was necessary to select an easily obtained indicator of transport. We reviewed several potential indicators of

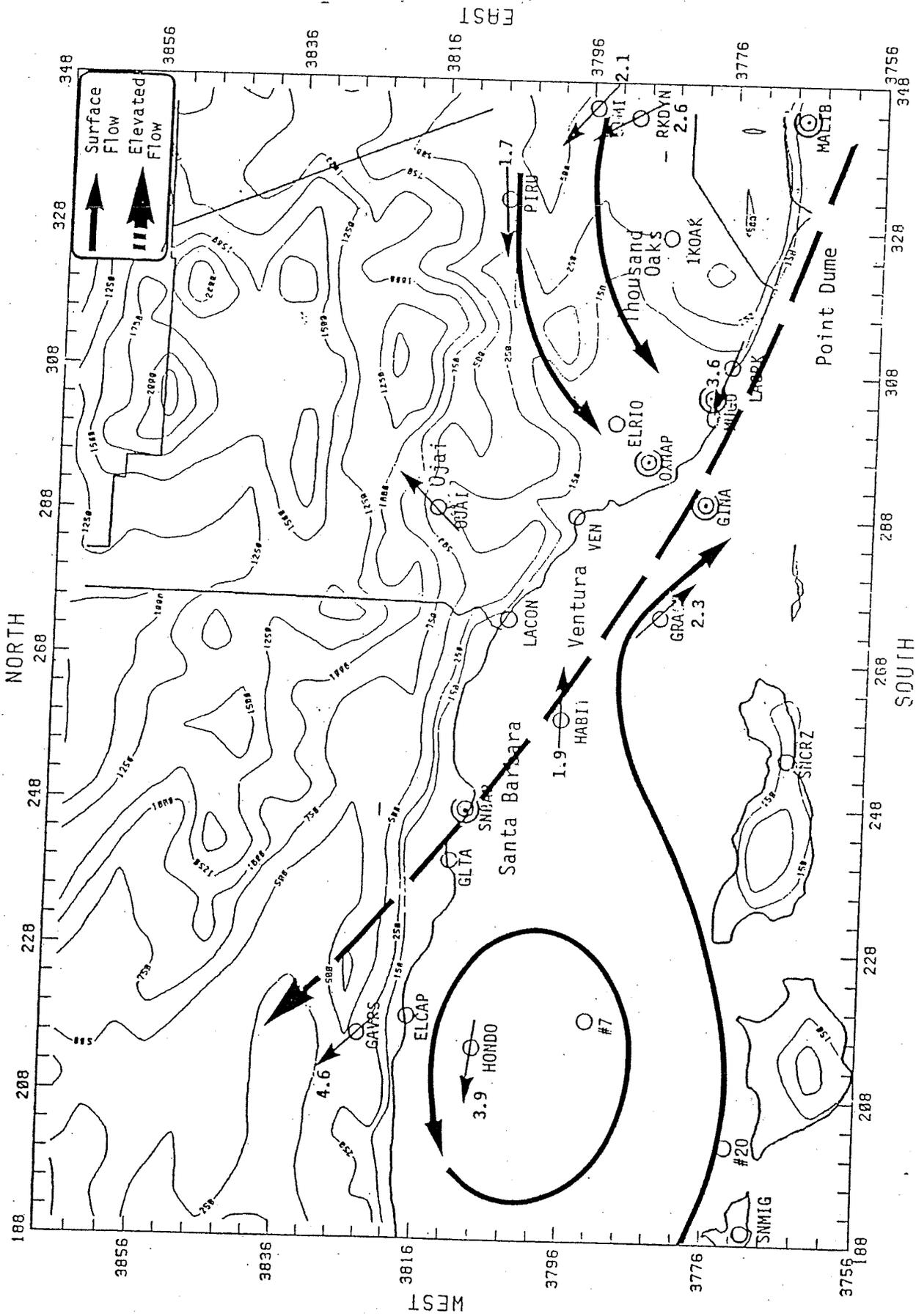


Figure 4-10. Prevailing Surface and Elevated Flow for High Ozone Days - 0600-0800 PST. (Wind speeds in m/s. C indicates calm.)

4-11  
5.1

Table 4-3. Ozone Maxima and Upper Winds for Exceedance Days during the VCOT Study -  
September 1 - October 6, 1983.

Date	Coastal Exceedances (pphm)/(Time PST)			Inland Exceedances (pphm)/(time PST)			Marymount <sup>+</sup> 0500 PST-1000mb	Winds Aloft (° True/m/s) Mugu - Mid AM 3000' msl	1000 PST Averag Doppler Winds in Transport Layer
	Ventura	El Rio	Laguna Peak*	Simi	Rocketdyne*	Piru			
Sept 3				13/11	15/11		098/0.5	M	99/8
4					14/12		305/0.5	M	-
5					16/11-13		125/0.5	M	-
6				15/13	17/13	13/12	200/1	128/4	-
7				14/10	15/10,12		220/1.5	130/4**	-
Sept 10				14/14			155/1	M	127/4**
11		14/15,16					140/0.5	M	164/6
12	15/12		13/11,12	23/13	28/12	17/12,13	070/2	M	127/13
13	13/15,16	13/13-16	14/19,20	16/12	18/11	15/12	205/1	132/2	128/10
14			14/11	15/11	19/11	14/12	080/1	120/1.5	-
15				15/13	17/12-13	13/12,13	M	230/0.5	161/3
16			17/20	15/12	14/10,12		240/1	128/1.5	137/2
17			15/22	17/13,14	18/11,12	14/13	090/1.5	088/2	118/4
18			15/15	15/14	14/13,14		300/1	135/0.5***	131/5
19	14/15		15/16		13/16		105/1	078/7.5	131/7
Oct 4				15/12	14/13		045/3.5	M	90/2

\* Elevated sites  
 \*\* Inversion level winds  
 \*\*\* 1300 PST winds  
 + Marymount soundings are made in West Los Angeles

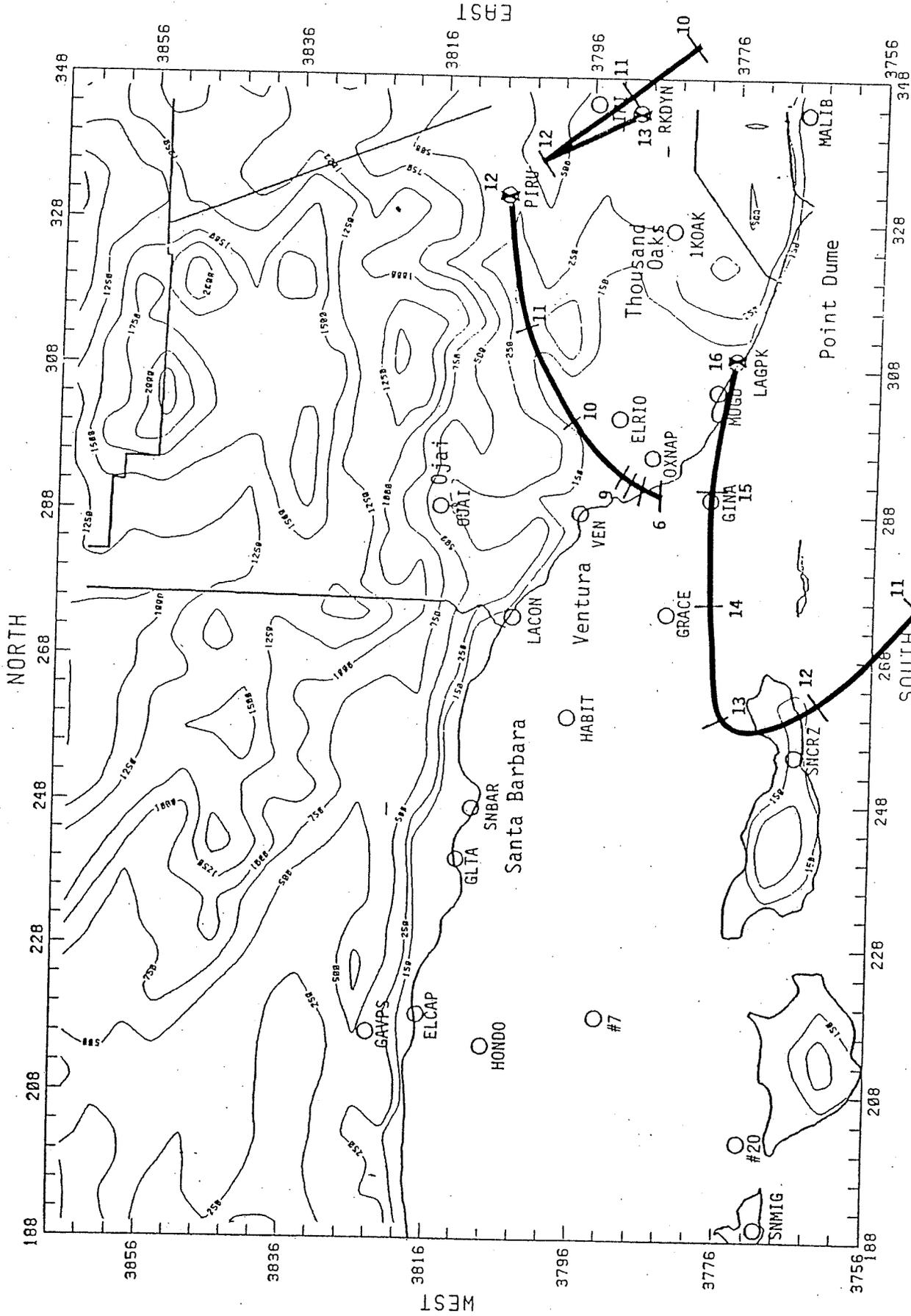


Figure 4-11. Surface Trajectories based on the Prevailing Winds for the Median Time of the Daily Ozone Maxima. (Times are in PST.)

transport such as the surface and elevated wind and various pressure gradients. The most direct indicator of transport is naturally the wind field. After examining the surface and upper air winds and their relation to surface ozone concentrations during the study period, we selected the 3000' wind direction from the Pt. Mugu 1000 PST rawinsonde as a good indicator of potential transport. Wind directions between  $45^{\circ}$  and  $180^{\circ}$  were assumed to indicate potential transport. This indicator was chosen for the following reasons:

- The transport mechanisms described in Section 3 involve an easterly flow component at either the surface or aloft. Typically easterly flow at the surface during the day is also accompanied by easterly flow aloft, but the opposite is not necessarily true; thus an elevated wind measurement was chosen.
- The transport conditions identified in Section 3 involve transport during the late night and midday hours. The 1000 PST measurement represents the mid-point of the various transport periods. Using the same criteria to define transport potential for the early morning or mid-afternoon Pt. Mugu rawinsondes, those soundings were found to give the same result as the 1000 PST sounding on 73% and 70% of the days, respectively, of a four year summer data set. Thus the 1000 PST sounding should be reasonably representative of the early morning through midday period.
- The 3000' msl altitude was chosen since this height is high enough to be out of the influence of local surface features and thus to be more regionally representative. Yet, it is low enough to still be near the top of the boundary layer flow. Determination of transport from the 3000' msl height gives the same result as the same determination from the 2000' msl height on 81% of the days in the four year data set mentioned above.
- The  $45^{\circ}$  to  $180^{\circ}$  directional criterion was used since those directions encompass virtually all of the trajectory directions from which material is likely to be transported from Los Angeles to Ventura County.

While the 3000' msl wind is suggested as an indicator of potential transport from Los Angeles County, the impact of the transport on Ventura County ozone concentrations is determined largely by the depth of the mixing layer which, in turn, is strongly influenced by the temperatures aloft (e.g. 850 mb).

## 5. RELATIONSHIPS OF HIGH OZONE IN VENTURA COUNTY TO TRANSPORT AND METEOROLOGICAL CONDITIONS.

### 5.1 DATA BASE USED TO EXAMINE POLLUTANT - METEOROLOGICAL RELATIONSHIPS AND TO ASSESS REPRESENTATIVENESS

In order to test hypotheses and examine relationships suggested by the September 1983 data and to evaluate the representativeness of the September 1983 field sampling period, a four year data base was assembled. This data base consists of daily records of the following parameters for June through October from 1980 to 1983:

- Daily hourly ozone maxima for each Ventura County APCD network site and for Rocketdyne (1981-1983 only).
- Daily maxima of the hourly average ozone concentrations measured at any Ventura County site including Rocketdyne.
- Daily ozone maxima for Los Angeles County monitoring sites at Lennox, West Los Angeles, Reseda, and Burbank.
- The 1000', 2000', and 3000' wind speed and direction at the Point Mugu Pacific Missile Test Range for the 0400 PST, 1000 PST, and 1600 PST observations.
- The 500', 1000', 2000', and 3000' wind speed and direction in the western Los Angeles Basin for the 0500 PST and 1100 PST observations (6/80 - 7/82 at UCLA/Westwood; 8/82 - 10/83 at Loyola-Marymont).
- The 850 mb temperature and height at Las Vegas (Bottle Rock) and Vandenberg AFB from the 0400 PST observations, and
- The 0400 PST surface pressure gradients from San Francisco to Reno and from Eureka to Reno.

In this section, this data base is used to examine the relationships of Ventura County ozone concentrations to meteorological parameters and to assess the contribution of intercounty transport to Ventura County ozone concentrations. In Section 6, the representativeness of the 1983 field sampling period compared to the long-term data base is examined. Some aspects of the four year data base have also been discussed in Section 3. Most of the data used in Sections 5 and 6 are listed in Appendix B.

The plots and tables in Sections 5 and 6 which use the data from Appendix B will have varying numbers of data points. For example, the number of data points available when stratifying by the Vandenberg 850 mb temperature will be different than when stratifying by the upper air wind direction at Pt. Mugu since the number of soundings at Pt. Mugu and Vandenberg are different.

### 5.2 RELATIONSHIP OF OZONE WITH 850 MB TEMPERATURE

Atmospheric stability is directly related to the temperature lapse rate. A rapid decrease in temperature with height is associated with

instability. Conversely weak, isothermal, and inverted (increase with height) lapse rates are associated with stable air. The temperature at 850 mb (about 1500 m) is widely used in California as an indicator of lapse rate, and hence regional air mass stability. With warm 850 mb temperatures, the vertical dispersion of pollutants is limited, thus, increasing the concentrations in the boundary layer.

The relationship of ozone levels to 850 mb temperature is clearly illustrated on Figures 5-1 and 5-2 and in Table 5-1. Figure 5-1 shows the frequency distribution of the 0400 PST Vandenberg 850 mb temperatures for the complete data set stratified by whether or not the federal ozone standard (12 pphm) was exceeded in Ventura County. From Figure 5-1, the most frequent temperature range increases from 16-18°C on non-exceedance days to 22-24°C on exceedance days. Figure 5-2 is a scatterplot of the 850 mb temperature versus the peak daily ozone maxima in Ventura County. Although the data exhibit a lot of variability, an increase of ozone concentration with temperature is evident. Even though the relationship between the variables is probably not linear, the linear regression line for the two variables is included in Figure 5-2 for reference purposes. Based on this regression line, an 850 mb temperature above about 20°C typically is associated with exceedance days ( $O_3 > 12$  pphm). The cumulative frequencies and averages of the 850 temperatures are given in Table 5-1. The average 850 mb temperature increases from 15.2°C on non-exceedance days to 21.2°C on exceedance days. Note that the 850 mb temperature was above 20°C on only 17% of the non-exceedance days as opposed to 66% of the exceedance days.

Table 5-1. Cumulative Frequencies of 0400 PST 850 mb Temperatures at Vandenberg for Ventura County Exceedance and Non-Exceedance Days (1980-1983)

850 mb Temp (°C)	Cumulative Frequency (%)	
	$O_3 < 12$ pphm	$O_3 > 12$ pphm
<10.0	16.2	0
<12.0	24.8	0
<14.0	39.5	0.4
<16.0	54.8	6.8
<18.0	72.6	19.6
<20.0	82.8	34.3
<22.0	92.4	55.1
<24.0	98.1	80.0
<26.0	99.4	92.5
<28.0	100.0	100.0
>28.0	100.0	100.0
Average Temperature	15.2°C	21.2°C

### 5.3 RELATIONSHIP BETWEEN VENTURA COUNTY OZONE CONCENTRATIONS AND THE OCCURRENCE OF TRANSPORT FROM LOS ANGELES TO VENTURA COUNTY

The processes by which pollutants from Los Angeles County contribute to ozone concentrations in Ventura County were described in Section 3. These transport processes were observed to occur on numerous occasions during the VCOT field study. However, the VCOT study was designed to look for such transport. To examine the frequency of occurrence of Los Angeles to Ventura

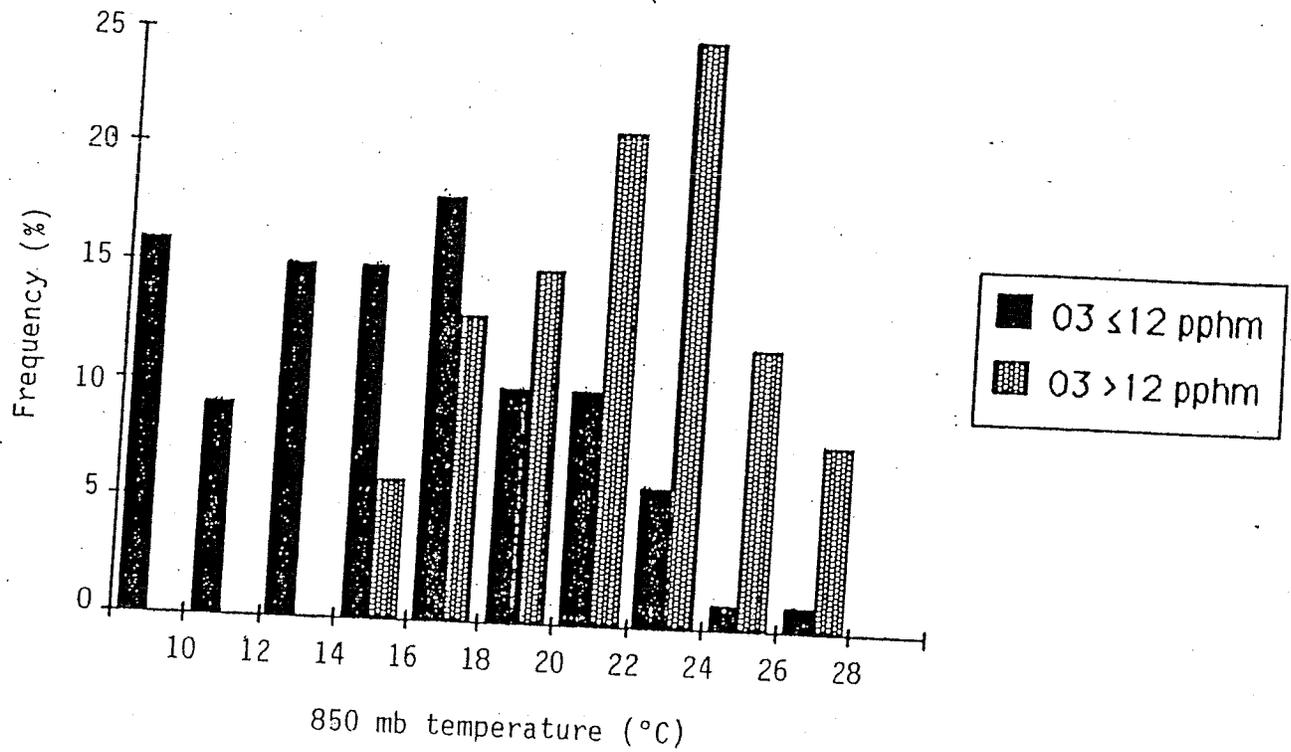


Figure 5-1. Frequency of Occurrence of 0400 PST 850 mb Temperatures at Vandenberg AFB for Exceedance and Non-exceedance Days in Ventura County for June-October, 1980-1983.

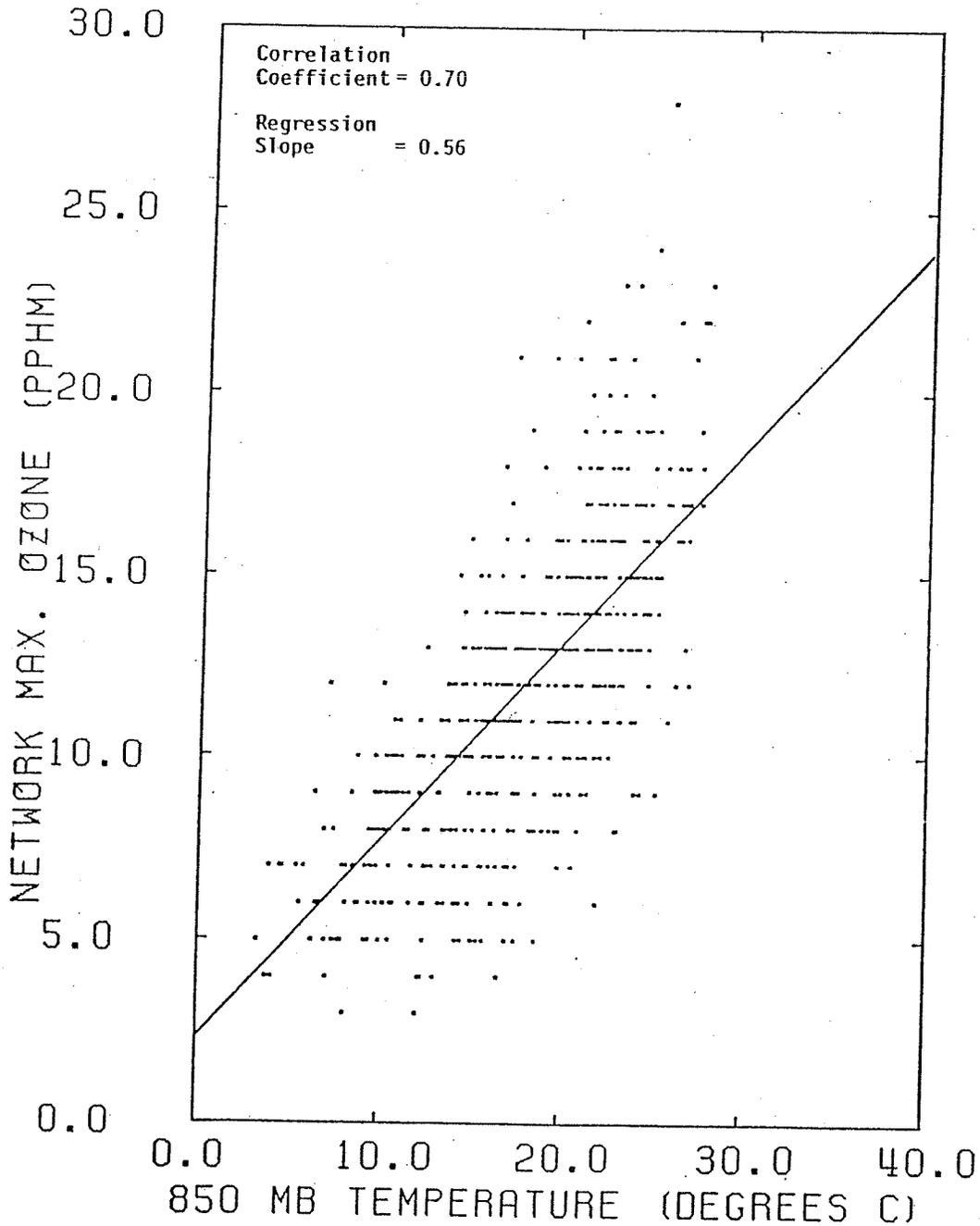


Figure 5-2. Ventura County Network Daily Maximum Hourly Ozone Concentrations as a Function of the 0400 PST Vandenberg AFB 850 mb Temperature for June-October, 1980-1983. (Note that the slope of the regression line visually appears too low. The line is correct, but is strongly influenced by variations in the density of points, especially those above the line between 10 degrees and 20 degrees C).

County transport over a longer time period and to get an idea of the transport contributions to Ventura County ozone concentrations, the 1980-1983 data base described in Section 5.1 was assembled, and the "transport" indicator described in Section 4.2 was selected.

Numerous analyses were performed on the four year data base to try to distinguish the effects of transport on specific monitoring stations and on Ventura County as a whole. From these analyses, we have found that there was the potential for transport on over half of the summer days in our data set and that the average ozone concentrations were higher at most Ventura County sites on "transport" days than on "non-transport" days. Selected analyses which demonstrate the frequency and effects of transport and the characteristics of transport days are presented in this section.

### 5.3.1 Frequency of Occurrence of "Transport" Days

As described in Section 4.2, we chose the 1000 PST 3000' wind direction at Pt. Mugu as an indicator of transport. Directions between  $45^{\circ}$  and  $180^{\circ}$  true were assumed to indicate transport. On most days, a positive occurrence is indicative of a regional boundary layer flow from Los Angeles to Ventura County during the morning hours. Even with this general flow however, surface sites might experience transport from a different direction due to terrain and thermally driven land-sea breeze influences.

Based on our "transport" indicator, the frequencies of occurrence of potential transport for the summer months in the four year data set are shown in Table 5-2. From this table, we can see that the potential for transport existed on half or more of all the days in each month and that August and September experienced a substantially higher frequency of transport than the other months. From this indicator, it is clear that the boundary layer air frequently flows from Los Angeles to Ventura County and that the transport phenomena should not be ignored when developing strategies for pollutant control in Ventura County.

Table 5-2. Frequency of Occurrence of Los Angeles to Ventura County Transport Winds. (Based on 1000 PST 3000 ft. Pt. Mugu rawinsonde data from 1980-1983.)

Month:	<u>June</u>	<u>July</u>	<u>August</u>	<u>September</u>	<u>October</u>	<u>TOTAL</u>
% of Days for $45^{\circ} < \text{WD} < 180^{\circ}$	50	52	71	69	51	59

### 5.3.2 850 mb Temperature Characteristics of "Transport" and "Non-Transport" Days

In Section 5.2, a strong relationship was shown between the morning 850 mb temperature and the daily maximum ozone concentration in Ventura County. In trying to distinguish the effects of transport phenomena on ozone concentration, it is important not to confound the effects of transport with other effects such as low mixing heights or trapping. Thus we have examined the relationship of 850 mb temperature to the occurrence of "transport" days. Figure 5-3 presents the frequency of 0400 PST 850 mb temperatures at Vandenberg for "transport" and "non-transport" days in the four year data base. From this figure, we can see that the median temperatures for "transport" and "non-transport" days are similar ( $18.6^{\circ}\text{C}$  for "transport",  $18.9^{\circ}\text{C}$  for "non-transport"). For warm days, above  $18-20^{\circ}\text{C}$ , the "non-transport" temperature distribution actually peaks at a higher temperature than the "transport" distribution. Since temperatures above  $20^{\circ}\text{C}$  are typically associated with ozone exceedances, we also examined the relative percentages of "transport" and "non-transport" days with 850 mb temperatures  $> 20^{\circ}\text{C}$  for each summer month (Figure 5-4). There are large variations in the percentages from month to month, but the seasonal averages are close together, with the "non-transport" average being slightly higher. From the temperature distributions alone, one might expect the "non-transport" days to have higher ozone than the "transport" days. Thus it is not likely that the meteorology which leads to "transport" necessarily is conducive to ozone formation. On the average, increases in ozone concentration in Ventura County on "transport" days compared to "non-transport" days can probably be attributed to the transport of ozone or precursors into Ventura County.

To further examine the 850 mb temperature characteristics of "transport" and "non-transport" days, we prepared temperature frequency distributions for both types of days broken down into exceedance ( $\text{O}_3 > 12$  pphm) and non-exceedance days for Ventura County. These distributions are shown in Figures 5-5 and 5-6. As expected, the high ozone days for both data sets have higher 850 mb temperatures than the lower ozone days. For the exceedance days, the peak of the distribution is a few degrees higher for "non-transport" days than for "transport" days. This suggests that a greater degree of trapping (lower inversions, shallower mixing) is needed to generate the same ozone concentrations on a "non-transport" day as on a "transport" day.

### 5.3.3 Ozone Characteristics of "Transport" and "Non-Transport" Days

To examine the pollutant characteristics in Ventura County of "transport" versus "non-transport" days, we calculated the percentages of "transport" and "non-transport" days which were exceedance days at each Ventura County site for each summer month. These percentages are presented in Table 5-3. For the five month period, for all sites but Ujai, a higher percentage of "transport" than "non-transport" days were exceedance days. This is true even though "non-transport" days have higher 850 mb temperatures on the average. Thus transport probably contributes significantly to Ventura County ozone concentrations.

The percentages in Table 5-3 vary greatly from month to month and site to site. A few of these variations are noteworthy. All exceedances at

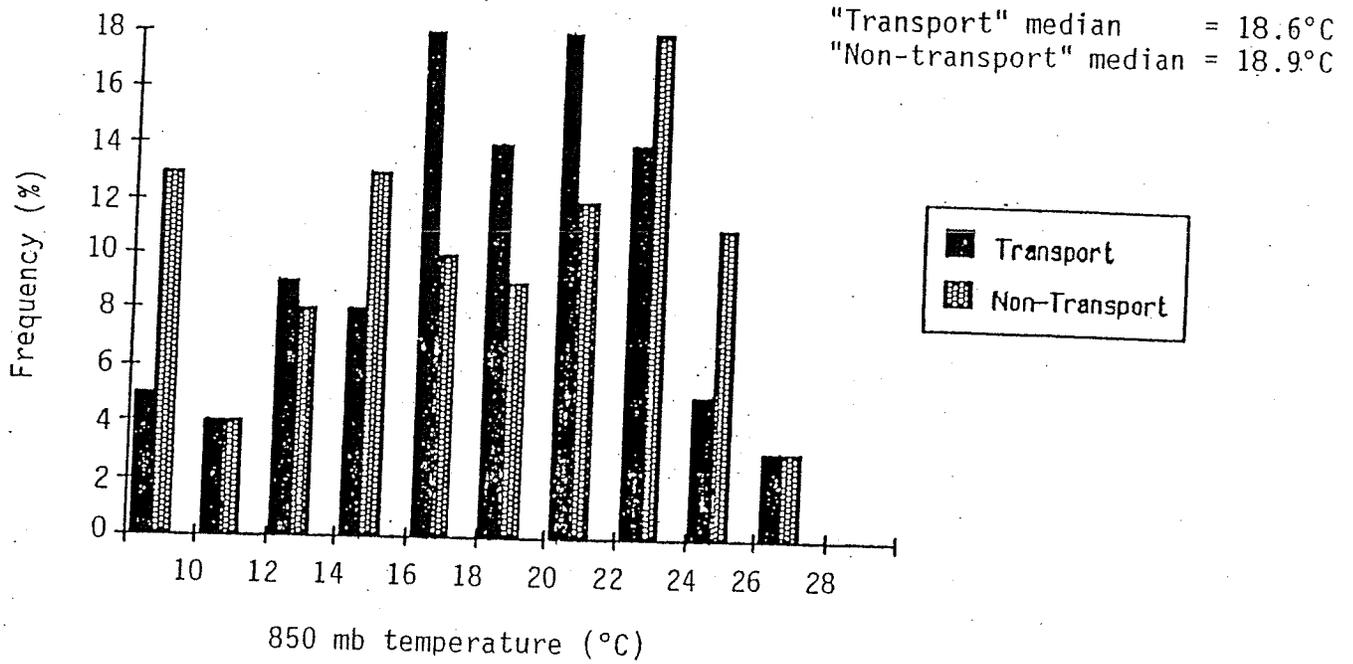


Figure 5-3. Frequency of Occurrence of 0400 PST 850 mb Temperatures at Vandenberg AFB for "Transport" and "Non-transport" Days for June-October, 1980-1983.

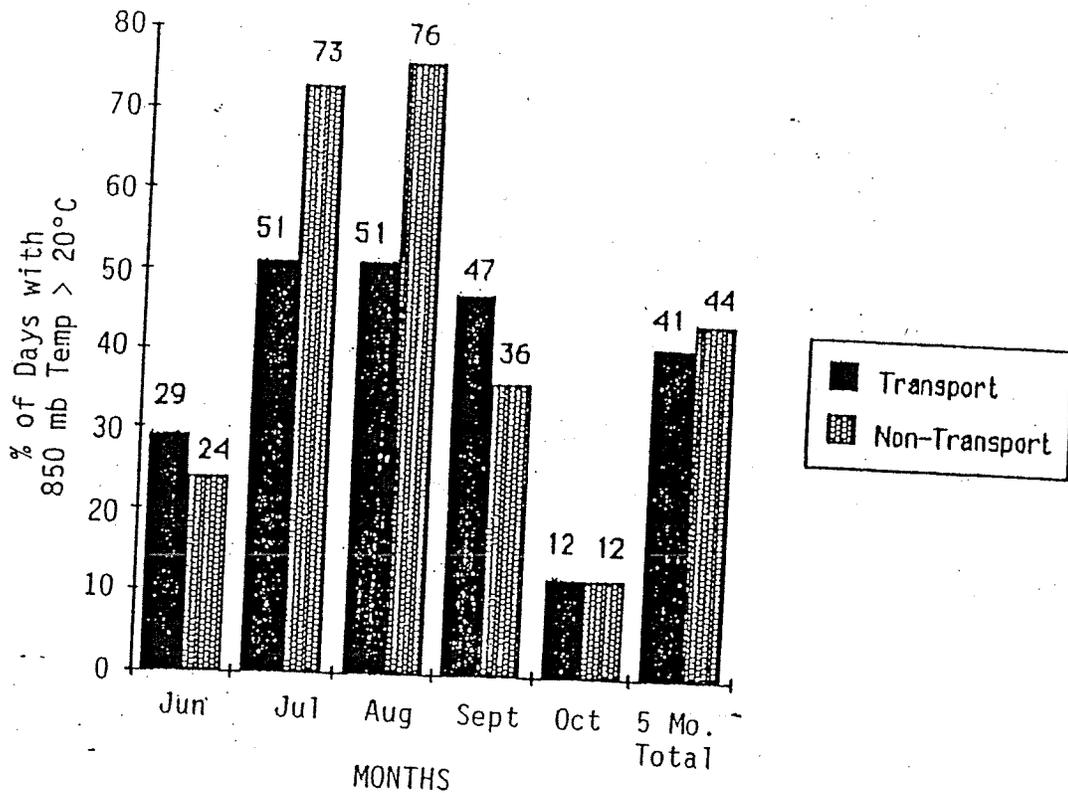


Figure 5-4. Percentages of "Transport" and "Non-transport" Days with Vandenberg AFB 0400 PST 850 mb Temperatures Greater than 20°C for 1980-1983.

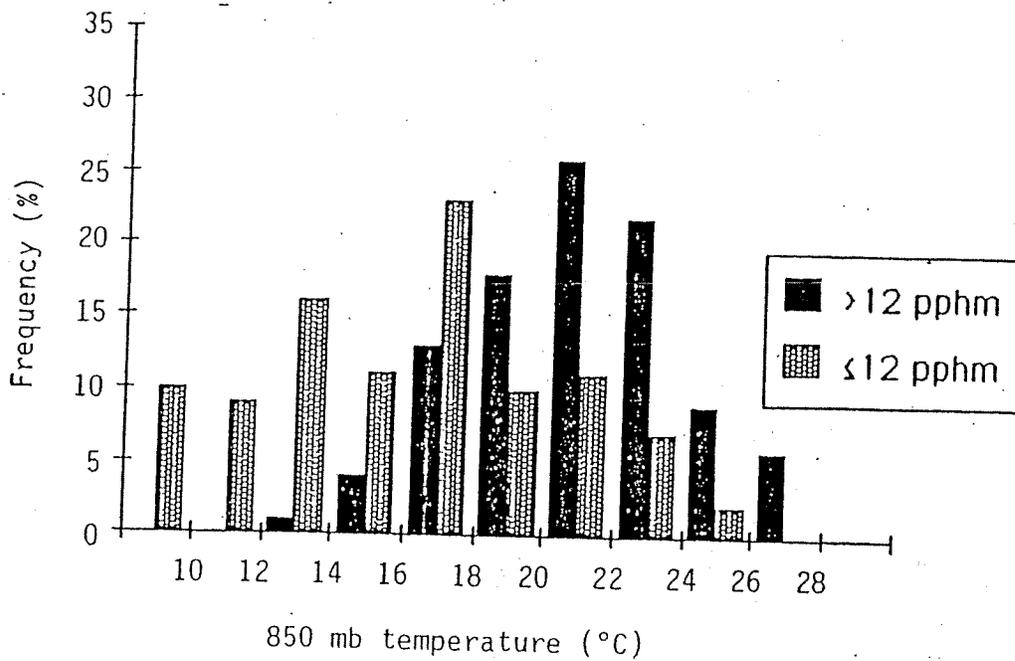


Figure 5-5. Frequencies of Occurrence of 0400 PST 850 mb Temperatures at Vandenberg AFB for Exceedance and Non-exceedance "Transport" Days for June-October, 1980-1983.

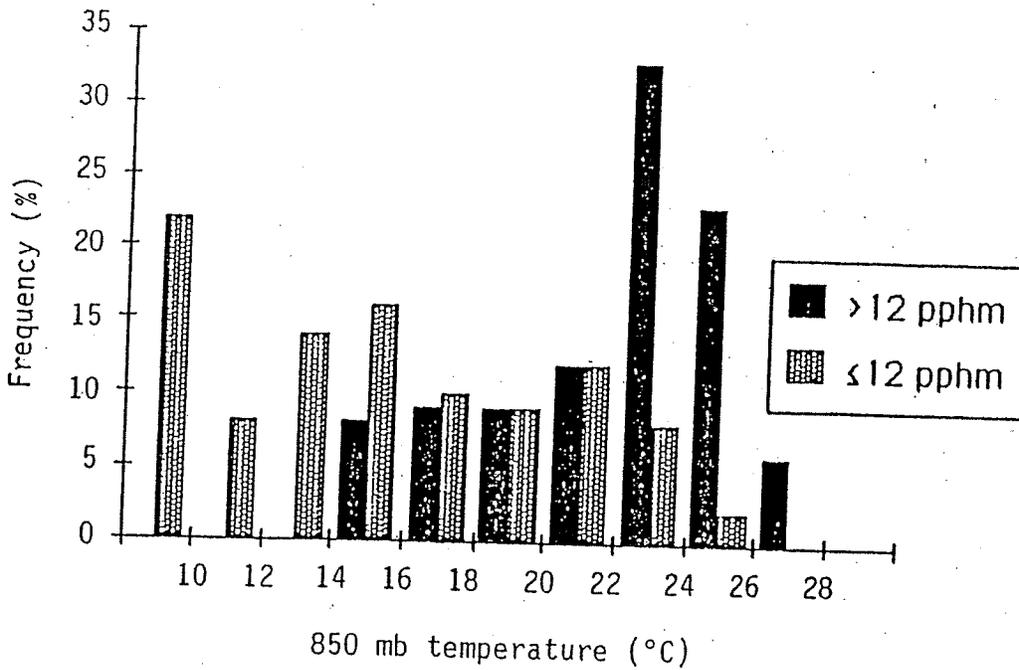


Figure 5-6. Frequencies of Occurrence of 0400 PST 850 mb Temperatures at Vandenberg AFB for Exceedance and Non-exceedance "Non-transport" Days for June-October, 1980-1983.

the coastal valley sites occurred on transport days. This probably implies that the coastal transport and recirculation mechanisms described in Sections 3.2.1 and 3.3.1 are required to accumulate enough ozone to exceed the standard on the coast. These mechanisms are unlikely to occur on "non-transport" days.

From Table 5-3, "transport" is clearly an important phenomenon during September. The percentage of "transport" days with exceedances in the county is about 2 1/2 times that of "non-transport" days, and all of the individual sites show a similar trend. The transport mechanisms described in Section 3 occur most frequently in September. The transport effect seems to be less pronounced in other months and also less strong in the northern part of the county (Simi, Piru) than along Highway 101 in the south (Thousand Oaks).

Table 5-3. Percentages of "Transport" and "Non-Transport" Days for Which Ozone Maxima at Ventura County Stations Exceeded 12 pphm, 1980-1983

Site	% of "transport" (T) or "non-transport" (N)											
	June		July		Aug		Sept		Oct		All 5 Months	
	T	N	T	N	T	N	T	N	T	N	T	N
Ventura Co. Max.	33	42	78	61	56	60	46	19	15	21	48	42
Ventura	2	0	2	0	0	0	5	0	3	0	3	0
El Rio	5	0	2	0	0	0	5	0	3	0	3	0
Ojai	16	12	24	25	10	24	15	8	11	10	15	16
Piru	20	12	39	39	16	21	28	12	14	14	24	21
Rocketdyne	15	35	74	65	60	57	41	22	5	9	43	39
Simi Valley	19	26	43	32	28	27	34	13	16	25	29	25
Thousand Oaks	6	3	10	9	10	5	13	0	17	14	11	7

The percentages of exceedance and non-exceedance days in Ventura County which were transport days are shown in Figure 5-7. The same percentages for each site are compiled in Table 5-4. The percentages of exceedance days which are also transport days clearly reach a maximum in September at all sites. County wide, 84% of all exceedance days in September were transport days while only 60% of non-exceedance days were transport days.

Many of the exceedance days in Table 5-3 are relatively low level exceedances of 13 or 14 pphm. To get an idea of the relationship of transport to higher levels of ozone in Ventura County, we prepared Figure 5-8. Figure 5-8 compares the percentages of "transport" and "non-transport" days which exceeded 12 pphm and 15 pphm. Although there were many fewer days which exceeded 15 pphm, the percentage of "transport" days which exceeded 15

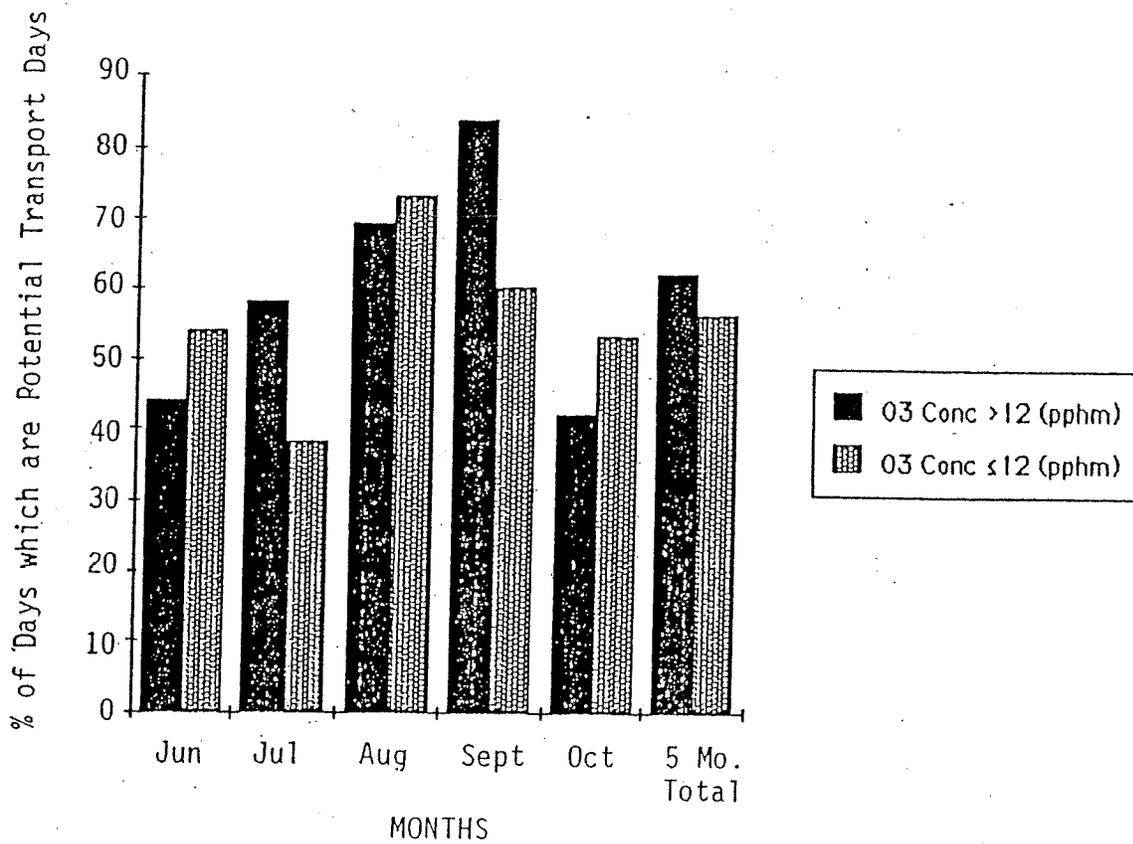


Figure 5-7. Percentages of Potential Transport Days by Month for 1980-1983 for Regional Maximum Ozone Concentrations Greater and Less than 12 pphm.

Table 5-4. Percentages of Exceedance and Non-exceedance Days which were "Transport" Days, 1980-1983.

	JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			FIVE MONTH TOTAL		
	% Trans	#Days	% Days	% Trans	#Days	% Days	% Trans	#Days	% Days	% Trans	#Days	% Days	% Trans	#Days	% Days	% Trans	#Days	% Days
El Rio	100	2	100	100	1	100	0	0	0	100	3	100	1	100	1	100	7	7
	Days >12	49	83	52	85	72	82	82	69	80	51	51	65	59	59	395	395	395
	Days ≤12	51	85	52	86	72	82	70	70	83	52	52	66	59	59	402	402	402
Ventura	100	1	100	100	1	100	0	0	100	3	100	1	100	1	100	6	6	6
	Days >12	49	83	52	85	71	86	68	68	81	49	49	85	58	58	400	400	400
	Days ≤12	50	84	52	86	71	86	69	69	84	50	50	66	59	59	406	406	406
Ojai	58	12	50	50	20	50	12	82	82	11	50	50	66	59	59	406	406	406
	Days >12	49	74	52	62	74	74	68	68	74	48	48	6	57	57	61	61	61
	Days ≤12	50	86	51	82	71	86	69	69	85	48	48	52	59	59	336	336	336
Piru	62	13	52	52	33	67	15	84	84	19	50	50	58	59	59	397	397	397
	Days >12	46	67	52	52	72	68	65	65	63	49	49	8	63	63	88	88	88
	Days ≤12	49	80	52	85	71	83	70	70	82	49	49	49	58	58	299	299	299
Rocket-	31	16	62	62	45	68	38	83	83	23	33	33	3	63	63	125	125	125
Dyne	58	48	53	53	19	65	26	66	66	41	50	50	42	59	59	176	176	176
	Days >12	42	64	59	64	67	64	72	72	64	49	49	45	60	60	301	301	301
	Days ≤12	52	64	59	64	67	64	72	72	64	49	49	45	60	60	301	301	301
Simi	50	67	50	50	50	72	22	86	86	21	44	44	9	64	64	102	102	102
Valley	50	86	54	54	81	72	57	63	63	56	58	58	36	59	59	266	266	266
Thousand Oaks	67	3	50	50	6	83	79	69	69	77	56	56	45	60	60	368	368	368
	Days >12	51	61	48	56	70	6	100	100	6	57	57	7	71	71	28	28	28
	Days ≤12	52	64	48	62	72	61	67	67	58	51	51	37	58	58	273	273	273
Regional	44	32	58	58	60	69	49	84	84	32	42	42	12	62	62	185	185	185
Maximum	54	54	38	38	26	73	37	60	60	53	53	53	55	56	56	225	225	225
	Days >12	50	86	52	86	71	86	69	69	85	51	51	67	59	59	410	410	410
	Days ≤12	50	86	52	86	71	86	69	69	85	51	51	67	59	59	410	410	410

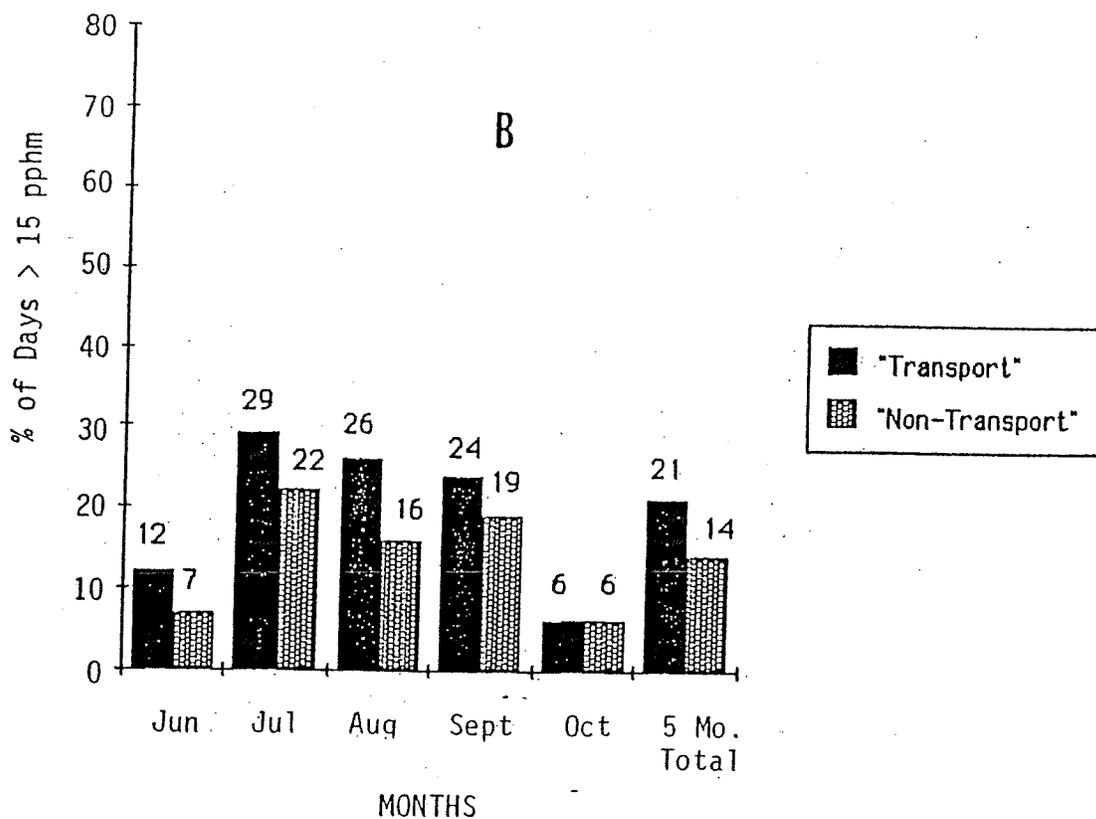
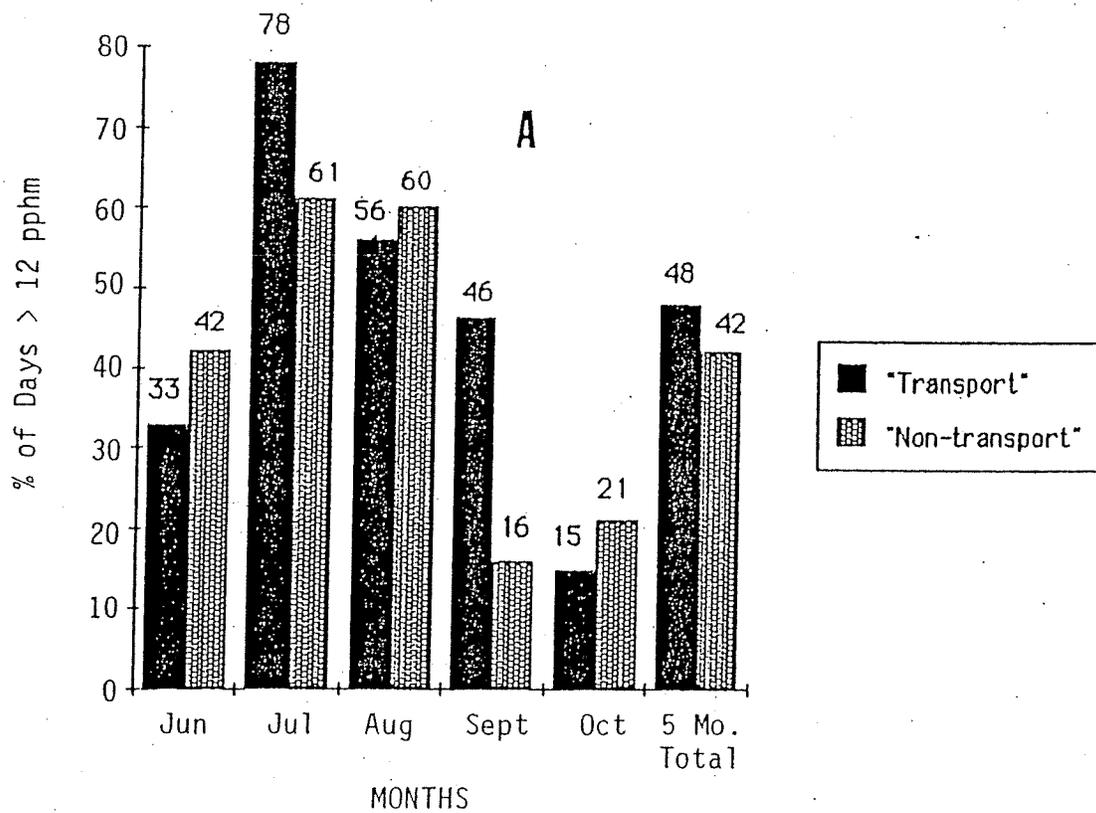


Figure 5-8. Percentages of "Transport" and "Non-transport" Days for which the Ventura County Ozone Maxima Exceeded (A) 12 and (B) 15 pphm, 1980-1983.

pphm was consistently higher than the percentage of "non-transport" days, 50% higher for the 5 month total. An examination of the percentage of those days with ozone maxima > 15 pphm which were "transport" days shows that 68% of the seasonal days above 15 pphm were "transport" days while only 59% of all seasonal days were "transport" days.

#### 5.3.4 Peak Ozone Concentrations on "Transport" Compared to "Non-Transport" Days

Section 5.3.3 showed that transport conditions were conducive to higher ozone concentrations in at least some months at all of the Ventura County monitoring sites in our data base. From the examples in Section 3 (and model results to be presented in Section 7) it is clear that transport from Los Angeles County can be responsible for most of the ozone at selected Ventura county sites under specific circumstances. To get an estimate of the typical contribution of transport to the ozone concentrations at each site for each month, we calculated the 50th and 90th percentile ozone maxima for each site for each of the 5 months for "transport" and "non-transport" days. The results are compiled in Table 5-5 on page 5-14 and are shown for September and for the 5 month total in Figures 5-9 and 5-10. Ventura County and upwind Los Angeles County sites are included. For most of the Ventura County sites and all months but June, the median and 90th percentile ozone maxima on "transport" days were 1-2 pphm higher than on "non-transport" days. For the Los Angeles County sites, the results were generally reversed. One exception was Ojai which didn't seem to see much effect from transport, except in the late summer. Another indicator of the effect of transport is the spatial gradient from east to west seen in Figures 5-9 and 5-10.

To obtain an estimate of the contribution of transport on days with similar stability characteristics, we performed regressions of the Ventura County maximum ozone values against the 850 mb temperature for each month for "transport" days and for "non-transport" days. Using the regression equations obtained, we calculated the predicted ozone concentrations at 20°C. The results are presented in Table 5-6. The ozone predictions for 20°C were slightly above the 12 pphm ozone standard in all cases but one, and the transport predictions were higher than the "non-transport" predictions for all months but June. The "transport" - "non-transport" differences ranged from -1.1 pphm to +1.9 pphm and averaged 0.7 pphm for the 5 month period.

Table 5-6. Predicted Maximum Hourly Ozone Concentration in the Ventura County Network for an 850 mb temperature of 20°C (Computed from linear regression equations for "transport" and "non-transport" days using the Vandenberg 0400 PST 850 mb Temperatures.)

	Ozone (pphm)					
	June	July	Aug	Sept	Oct	5 Mqs. Combined
"Transport"	12.7	14.3	13.3	13.3	12.6	13.3
"Non-transport"	13.8	12.4	12.4	12.6	11.8	12.6
Difference	-1.1	1.9	0.9	0.7	0.8	0.7

Table 5-5. Daily Maximum and 90th Percentile Ozone Concentrations for Transport and Non-transport Days (1980-1983).

Site	Statistics for Complete Four Year Data Set																			
	June			July			August			September			October			All Five Months				
	50%	90%	90%	50%	90%	90%	50%	90%	90%	50%	90%	90%	50%	90%	90%	50%	90%	90%		
El Rio	6/6	9/10	8/6	11/8	6/6	9/8	7/5	11/9	6/6	10/9	7/6	10/9	50%	90%	90%	50%	90%	90%	50%	90%
Yentura	6/7	9/9	7/5	10/8	6/5	8/8	7/5	10/8	6/6	9/9	6/6	10/9	7/5	11/9	6/6	10/9	7/6	10/9	7/6	10/9
Ojai	9/10	13/13	11/11	15/14	10/11	12/14	9/8	13/12	7.5/6	13/12	9/10	13/13	13/12	7.5/6	13/12	9/10	13/13	13/13	9/10	13/13
Piru	8/9	15/13	12/12	15/14	10/10	14/15	11/8	16/13	6/5	15/13	10/9	15/14	11/8	16/13	6/5	15/13	10/9	15/14	10/9	15/14
Rocketdyne	10/11	13/15	14/13	19/17	13/13	21/18	10.5/9	18/18	9.5/7	12/12	12/11	18/17	10.5/9	18/18	9.5/7	12/12	12/11	18/17	12/11	18/17
Simi Valley	10/11	13/14	12/11	17/15	11/10	15/14	10/8	15/15	9/8	15/14	11/10	15/15	10/8	15/15	9/8	15/14	11/10	15/15	11/10	15/15
1000 Oaks	7/8	10/10	10.5/9	12.5/12	8.5/9	13/11	9/6	13/12	9/7	15/13	9/8	13/12	9/6	13/12	9/7	15/13	9/8	13/12	9/8	13/12
Burbank	10/12	19/18	14/15	20/23	12/18	21/24	13/12	24/25	8.5/7	24/16	12/13	21/22	13/12	24/25	8.5/7	24/16	12/13	21/22	12/13	21/22
Reseda	11/13	17/18	12/14	19/22	12/14	19/23	12/11	20/21	7/7	14/21	11/12	19/21	12/11	20/21	7/7	14/21	11/12	19/21	11/12	19/21
Lennox	4/5	8/9	5/5	8/8	5/6	8/10	5/4	8/8	5/4	8/7	5/5	8/9	5/4	8/8	5/4	8/7	5/5	8/9	5/5	8/9
West L.A.	7/8	13/15	8/10	13/14	8/12	13/16	9/8	15/17	7/7	14/13	8/8	14/15	9/8	15/17	7/7	14/13	8/8	14/15	8/8	14/15
Yen Co. Max	11/11	16/15	14/13	18/17	13/13	20/18	12/9	17/17	9.5/8	15/14	12/11	18/17	12/9	17/17	9.5/8	15/14	12/11	18/17	12/11	18/17

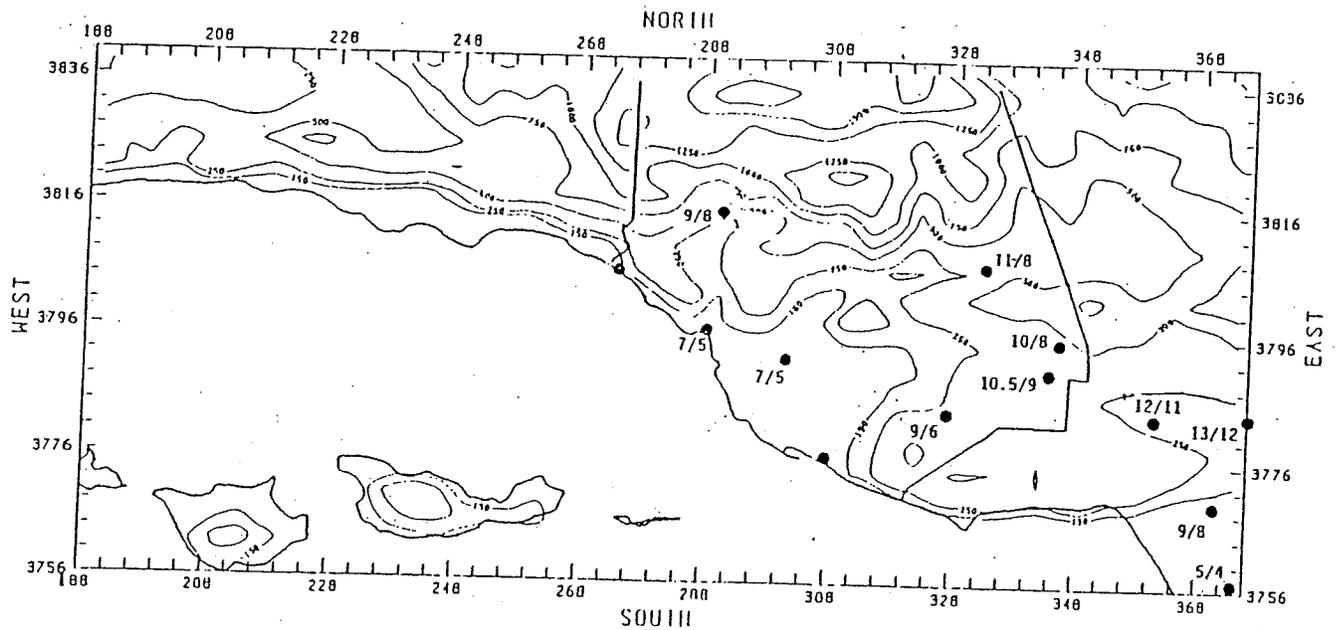


Figure 5-9. Median Daily Ozone Maxima on "Transport" Days and "Non-transport" Days for September, 1980-1983. (Units are pphm; "transport"/"non-transport".)

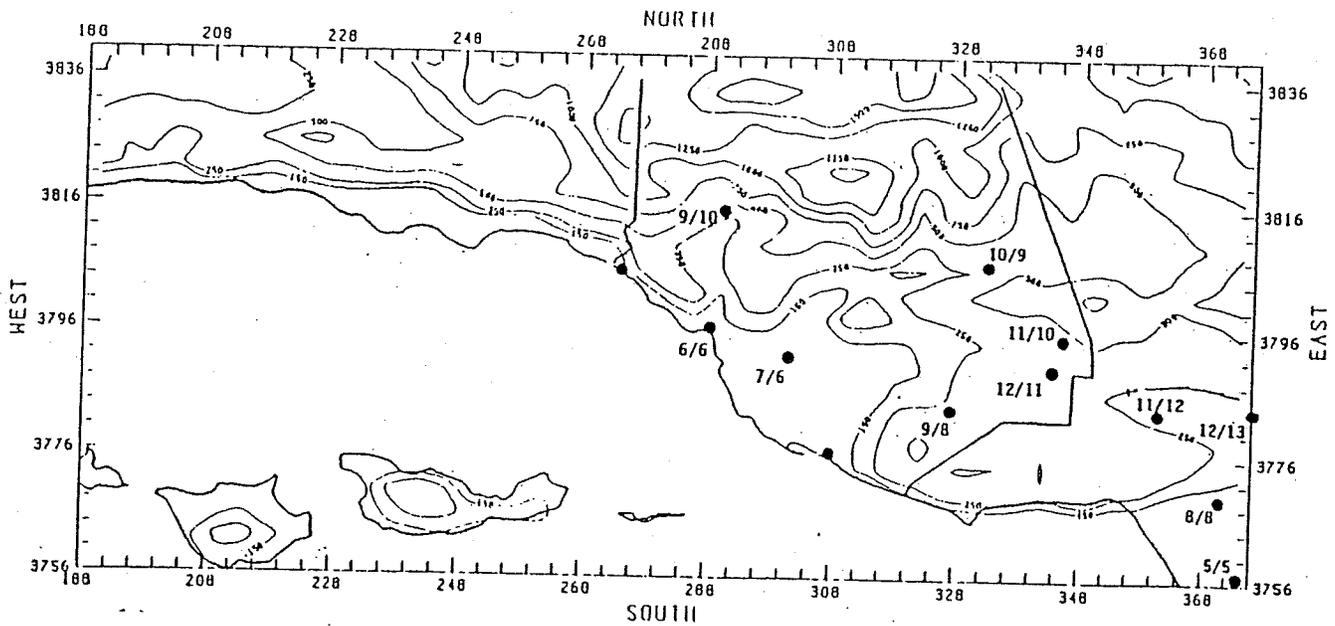


Figure 5-10. Median Daily Ozone Maxima on "Transport" Days and "non-transport" Days for June-October, 1980-1983. (Units are pphm; "transport"/"non-transport".)

## 6. REPRESENTATIVENESS OF THE SEPTEMBER FIELD STUDY PERIOD

### 6.1 INTRODUCTION

To assess the representativeness of the field study period, selected air quality and meteorological parameters for September 1983 were compared with data from 1980-1983. The field study period was assessed from two view points: 1) how representative is September in general compared with the other months in the ozone season, and 2) how representative was the sampling period compared with other September periods. Atmospheric stability representativeness was assessed by examining the Vandenberg AFB 0400 PST 850 mb temperatures. The potential for Los Angeles to Ventura County transport was assessed by comparing the winds aloft measured at Pt. Mugu. Air quality representativeness was assessed by examining the ozone measured at sites which had a sufficient long-term record and were operational during the field study.

The meteorology during the field study exhibited several anomalous features. On six successive days, the 850 mb temperature exceeded the 90th percentile of the long-term September data base. This six-day period accounted for 67% of the September occurrences of temperatures greater than 24°C during the four-year period. This suggests greater atmospheric stability than is typical in September. In contrast, the last two weeks of the field study (September 21 to October 6) were characterized by extensive cloudiness, rain showers, and generally low ozone concentrations due to a series of low pressure systems off the Southern California coast. These systems caused an increase in the frequency of Los Angeles to Ventura County transport winds. Nevertheless, the number of ozone exceedances (> 12 pphm) in Ventura County during the field study was comparable to the other September periods examined.

### 6.2 850 MB TEMPERATURE ASSESSMENT

A strong relationship between the 850 mb temperature at Vandenberg AFB and ozone levels in Ventura County was shown in Section 5. Table 6-1 shows the combined monthly and seasonal frequency distributions of the 0400 PST (12 GMT) 850 mb temperatures at Vandenberg for the 1980 to 1983 oxidant seasons. The data in the table are given in terms of cumulative frequency. The number of occurrences within each 2°C temperature range is shown in parentheses. Monthly and seasonal average temperatures are also given in the table.

The maximum average temperature during the oxidant season was experienced in August (20.6°C) and the minimum average temperature experienced in October (13.9°C). In August, over 60% of the 850 mb temperatures exceeded 20°C, whereas in October, only 8.9% exceeded 20°C. In September, the average 850 mb temperature was 18.1°C, and on 42% of the days the temperature was greater than 20°C. The September 850 mb temperature distribution exhibited a blend of the August and October temperatures, reflecting the transition in September from summer to fall conditions. This feature is clearly shown in Figures 6-1 and 6-2. Figure 6-1 is a histogram of the 850 mb temperature distributions for August and October. Figure 6-2 includes a histogram of the 850 mb temperature distribution for September. The figures show the most frequent temperature range of the

Table 6-1. Average and Frequency of Occurrence by Month of 0400 PST  
Vandenberg 850 mb Temperatures

Temp (°C)	Cumulative Frequency (%) (number of occurrences shown in parentheses)					Five Mo. Total
	June	July	Aug	Sept	Oct	
≤ 10.0	11.1(10)	0(0)	3.3(4)	8.5(10)	21.8(27)	8.8(51)
10.1-12.0	18.9(7)	0(0)	4.1(1)	12.7(5)	33.1(14)	13.5(27)
12.1-14.0	30.0(10)	5.6(7)	5.7(2)	22.9(12)	46.0(16)	21.6(47)
14.1-16.0	47.8(16)	16.1(13)	10.6(6)	30.5(9)	62.9(21)	32.8(65)
16.1-18.0	58.9(10)	31.5(19)	19.5(11)	44.1(16)	90.3(34)	48.4(90)
18.1-20.0	74.4(14)	43.5(15)	39.8(25)	57.6(16)	91.1(1)	60.6(71)
20.1-22.0	81.1(6)	63.7(25)	65.9(32)	76.3(22)	91.1(0)	75.3(85)
22.1-24.0	95.6(13)	85.5(27)	82.1(20)	92.4(19)	95.2(5)	89.8(84)
24.1-26.0	100.0(4)	94.4(11)	91.1(11)	99.2(8)	97.6(3)	96.2(37)
26.1-28.0	100.0(0)	100.0(7)	100.0(1)	100.0(1)	100.0(3)	100.0(22)
> 28.0	100.0(0)	100.0(0)	100.0(0)	100.0(0)	100.0(0)	100.0(0)
Average Temp. (°C)	16.7	20.2	20.6	18.1	13.9	18.0

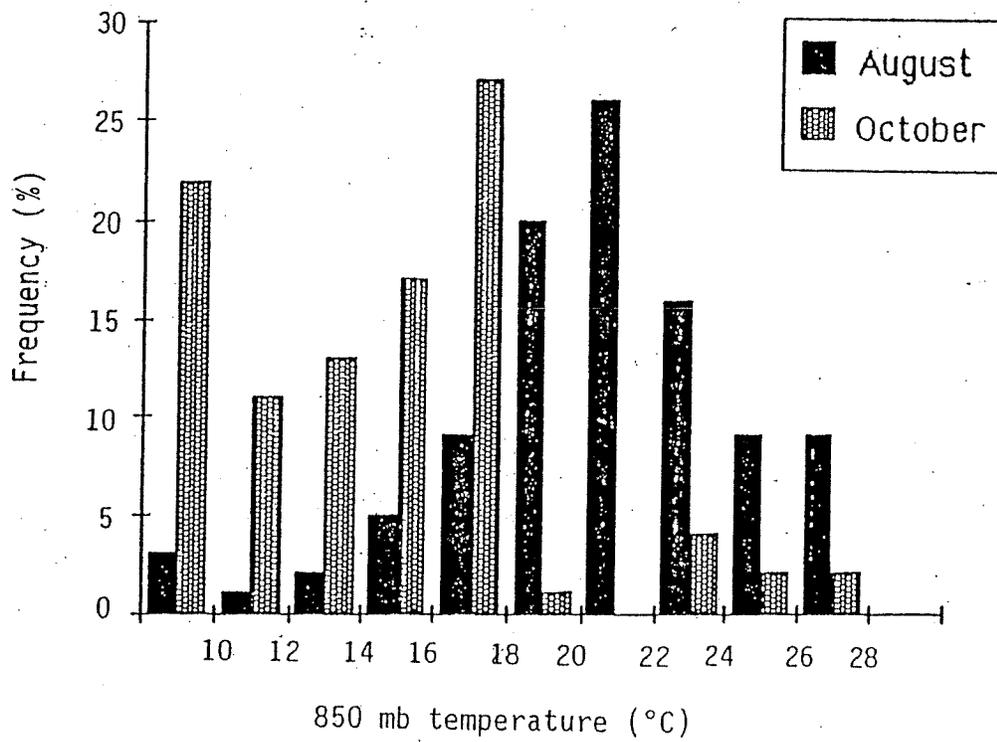


Figure 6-1. Frequency of Occurrence of Vandenberg AFB 0400 PST 850 mb Temperatures During August and October, 1980-1983.

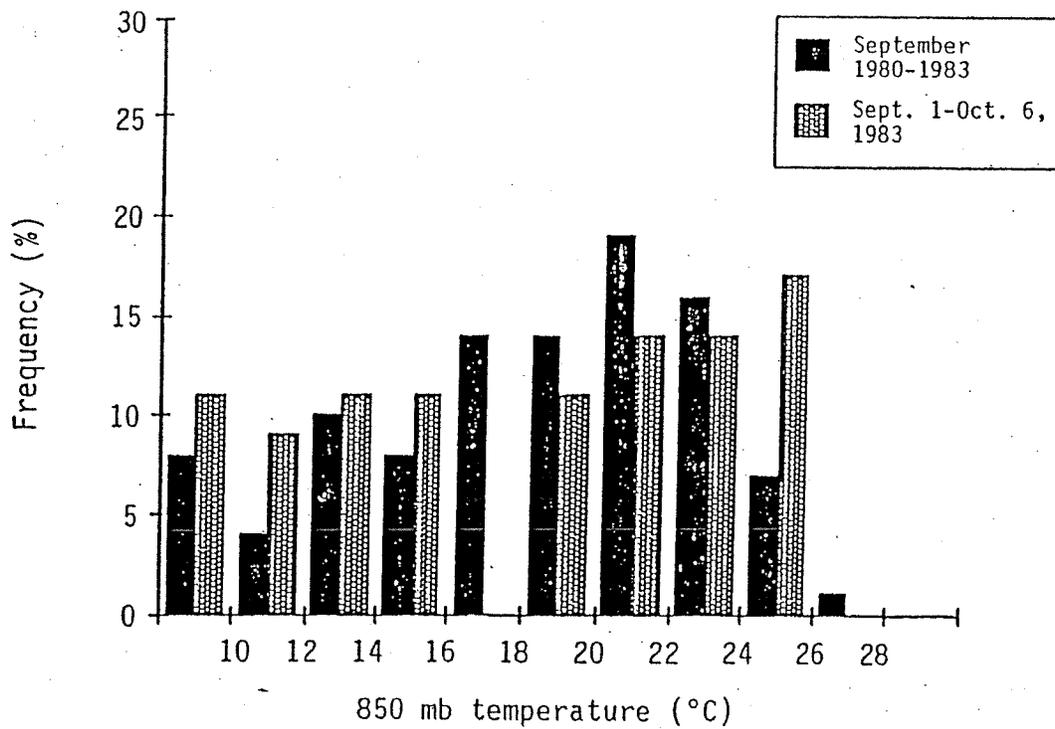


Figure 6-2. Frequency of Occurrence of Vandenberg AFB 0400 PST 850 mb Temperatures During September 1980-1983 and During the VCOT Study Period.

Vandenberg 850 mb temperatures for both August and September to be 20<sup>o</sup>-22<sup>o</sup>. On the other hand, like October, the September data also show a large number of occurrences of temperatures less than 18<sup>o</sup>C. From Table 6-1, it is also seen that the September 850 mb temperatures are distributed remarkably similarly to the seasonal (June through October) data. The seasonal average 850 mb temperature is 18<sup>o</sup>C, and 39% of the seasonal temperatures exceed 20<sup>o</sup>C.

The frequency distribution of Vandenberg 0400 PST 850 mb temperatures for the VCOT sampling period is compared in Table 6-2 to that for the Septembers of 1980-1983. The data in the table are shown as cumulative frequencies. The numbers of occurrences are shown in parentheses. In Figure 6-2 the same data are presented in histogram form. A notable feature of the data is the distribution above 24<sup>o</sup>C or the 92nd percentile of the September 1980-1983 data. Sixty-seven percent of those occurrences were in 1983. These extremes occurred in one six-day period from September 11 to 16. The long-term and 1983 data show some notable similarities as well. For both temperature distributions, there is a tendency for the data to fall into two groups; one group consisting of the warm summer type conditions and a second consisting of the cooler fall type conditions. The 1983 data in Figure 6-2 most clearly illustrate this feature. Temperatures ranged from 18.1<sup>o</sup>C to 24<sup>o</sup>C for one group of days and ranged from 16<sup>o</sup>C down in a second group of days. There were no occurrences of 850 mb temperatures from 16.1<sup>o</sup>C to 18<sup>o</sup>C. From Table 6-2 it can be seen that, although temperature extremes were experienced in 1983, the two data sets had similar percentages of occurrences less than and above the 20<sup>o</sup>C level. In Section 5, 20<sup>o</sup>C was used as an indicator to distinguish days which were likely to have high ozone values.

The daily 0400 PST Vandenberg 850 mb temperatures during the field program are plotted in Figure 1-3. The September 1980-1983 average temperature is shown as a dashed line. Features of the sampling period discussed above are illustrated in the figure. The September 1-20 period was characterized by warmer than average temperatures aloft. After September 20, the 850 mb temperatures cooled and remained below average for the remainder of the sampling period. Temperatures above the long-term September 92nd percentile (24<sup>o</sup>C) were experienced from September 11 to 16. (Note that the ozone standard was exceeded on each of those days.)

### 6.3 TRANSPORT ASSESSMENT

It was shown in Section 4 that all of the exceedance days in Ventura County during the field program occurred when the flow aloft was directed from Los Angeles County. Specifically, the 1000 PST (18 GMT) 3000 ft-msl winds at Pt. Mugu proved to be a good indicator of the potential for intercounty transport when the direction was between 45<sup>o</sup> and 180<sup>o</sup>. On this basis, each day during the oxidant season (June-October) from 1980 to 1983 when Pt. Mugu data were available was classified as either as a "transport" or "non-transport" day. The percentage of days in each month that "transport" winds occurred are shown in Table 6-3. During the five month oxidant season, "transport" winds occurred on 59% of the days. August (75%) and September (69%) experienced the highest frequencies of occurrence. "Transport" winds occurred on about half the days during June, July, and October.

Table 6-2. Average and Frequency of Occurrence of 0400 PST Vandenberg 850 mb Temperatures for September (1980-1983) and for VCUT Sampling Period

Temp ( $^{\circ}$ C)	Cumulative Frequency (%) (number of occurrences shown in parentheses)	
	September 1980-1983	1 September 1983 to 6 October 1983
<10	8.5(10)	11.4(4)
<10.1-12.0	12.7(5)	20.0(3)
<12.1-14.0	22.9(12)	31.4(4)
<14.1-16.0	30.5(9)	42.9(4)
<16.1-18.0	44.1(16)	42.9(0)
<18.1-20.0	57.6(16)	54.3(4)
<20.1-22.0	76.3(22)	68.6(5)
<22.1-24.0	92.4(19)	82.9(5)
<24.1-26.0	99.2(8)	100.0(6)
<26.1-28.0	100.0(1)	100.0(0)
>28	100.0(0)	100.0(0)
Average Temperature ( $^{\circ}$ C)	18.1	17.7

Table 6-3. Frequency of Occurrence (%) of Los Angeles to Ventura County Transport Winds

Jun.	Jul.	Aug.	Sept.	Oct.	Combined	Sept. 1983
50	52	71	69	51	59	77

(Based on 1980-1983 Pt. Mugu 1000 PST winds when available.)

It should be noted, that transport from Los Angeles County may or may not cause poor air quality in Ventura County. Wind direction only indicates the probable source of the air aloft. Other factors which take into account the air mass history and dispersion characteristics determine the air quality impact. In fact, in this data base only 48% of the "transport" days were exceedance days ( $O_3 > 12$  pphm).

From Table 6-3 it is seen that September 1983 had a greater than usual occurrence of transport days (77%). This feature was due in part to the extended period of southerly flow aloft experienced after September 20th as a result of an unusual succession of closed low pressure systems offshore of the Southern California coast. This period was characterized by generally low ozone levels and no exceedances in Ventura County.

## 6.4 OZONE ASSESSMENT

The number of days on which the Federal ozone standard (12 pphm) was exceeded during 1978-1983 is shown in Table 6-4. These data are extracted from the California Air Quality Summaries (CARB, 1978-1983). The data are shown as the average number of exceedances for each month of the oxidant season (June through October) at four locations in Ventura County, one (Goleta) in Santa Barbara County, and four in Los Angeles County. Lennox and West Los Angeles are representative of Los Angeles County upwind ozone levels when the trajectory from Los Angeles County to Ventura County is offshore. Burbank and Reseda, in the San Fernando Valley are representative upwind sites when the transport trajectory to Ventura County is inland. The data in the table are organized such that the coastal (or coastal plain) sites, the Ventura County inland valley sites, and the Los Angeles County inland sites are grouped together.

The inland sites experienced the maximum number of exceedances in July and the fewest in October. An equal number of exceedances were experienced at the inland sites in August as in September. There was about a 50% increase in July exceedances over exceedances in August or September at the inland locations. The ratio of the July to September number of exceedances was 1.66, 1.50, and 1.62 for Simi, Piru, and Ujai, respectively.

Table 6-4. Average Number of Occurrences per Month of Daily Ozone Concentrations > 12 pphm During July-October from 1978 through 1983

Name	Site	Location	Jun.	Jul.	Aug.	Sept.	Oct.
Goleta	Santa Barbara Co.-Coastal		.3	.3	.5	1.3	0
El Rio	Ventura Co.-Coastal		.5	.2	.3	2.3	.8
Lennox	Los Angeles Co.-Coastal		.6*	.3	.5	1.5	.2
Ujai	Ventura Co.-Inland Valley		3.4*	6.8*	4.8*	4.2	3.3
Piru	"	"	4.2*	10.8*	6.6*	7.2*	2.6*
Simi	"	"	7.5	13.3	10.7	8.0	5.2
West L.A.	L.A. Co.-Inland		4.4*	5.8*	6.0*	8.3	3.7
Reseda	L.A. -Inland Valley		14.7	18.5	15.3	15.8	6.8
Burbank	"	"	13.7	21.5	19.8	17.8	8.7

\* Based on only 5 years of records.

The coastal locations (El Rio, Goleta, and Lennox) exhibited an entirely different pattern. These sites experienced very few ozone exceedances, but those that did occur were most likely to occur in September. The number of exceedances in September was greater than or equal to the number experienced during the remainder of the smog season. The coastal exceedances most frequently occurred during post-Santa Ana conditions. During Santa Ana winds, Los Angeles Basin air is transported offshore. When the prevailing westerly onshore flow is reestablished, primarily the coastal sites are impacted.

The above features also show up in the monthly average of the daily ozone maxima given in Table 6-5. These data were extracted from the 1980-1983 data base. The additional Ventura County sites at Rocketdyne and Thousand Oaks are included in this table. Portions of our Ventura (city) data were suspected to be in error and are not included in the table. Note that even on the average, El Rio on the Ventura County coastal plain experienced peak ozone levels in September. The averages at the inland monitoring sites peaked in either July or August.

Table 6-5. Monthly Average of the Daily Ozone Maxima (pphm) from 1980-1983

Site	June	July	Aug.	Sept.	Oct.
El Rio	6.7	7.0	6.3	7.2	6.1
Thousand Oaks	8.0	9.6	8.8	8.6	8.1
Rocketdyne	10.7	13.5	13.7	11.4	7.7
Simi Valley	10.5	11.6	10.7	10.0	8.2
Piru	9.2	11.1	10.6	9.9	6.9
Ujai	9.3	10.7	10.3	9.2	7.3
Burbank	12.1	15.3	14.6	13.5	8.8
Reseda	12.1	14.1	13.4	12.2	8.5
Lennox	5.6	5.6	5.8	5.5	5.2
West L.A.	8.9	9.8	9.8	9.6	7.7

The ozone data suggest that the causes of high oxidant levels in Ventura County are seasonally dependent and that September, more than any other month, experiences a variety of the conditions which result in high ozone levels at both coastal and inland locations in Ventura County.

The September data in Table 6-4 are presented in more detail in Table 6-6. The latter table shows the number of exceedances by year and the average number of monthly exceedances for the six-year period (1978-1983). The 1983 ozone experience closely resembles the longer-term average and is well within the year-to-year variability shown in the table. Exceedances occurred on the Ventura coastal plain on three consecutive days during the sampling period (September 11-13). El Rio measured exceedances on September 11 and 13 and Ventura (not shown in the table) on September 12 and 13. Goleta, in Santa Barbara County, had exceedances on three days in 1983; the highest frequency during the 6 year period. September 11 and 12 were operational sampling days on which detailed air quality and meteorological data were collected and analyzed.

Table 6-6. Number of Occurrences of Daily Maximum Ozone Concentration  
> 12 pphm For September 1978-1983

Location	1978	1979	1980	1981	1982	1983	1978-1983 Average
Goleta	1	2	0	1	1	3	1.3
El Rio	3	6	0	3	0	2	2.3
Lennox	4	2	0	0	1	2	1.5
Ujai	2	8	6	3	3	3	4.2
Piru	-	11	9	9	1	6	7.2
Simi	8	14	4	10	2	10	8.0
West L.A.	9	13	6	5	7	10	8.3
Reseda	9	19	20	25	8	14	15.8
Burbank	15	23	19	20	11	19	17.8

## 7. MODEL SIMULATIONS OF TRANSPORT AND LOCAL CONTRIBUTIONS TO SURFACE OZONE CONCENTRATIONS FOR SELECTED TRAJECTORIES.

Some exploratory photochemical modeling was performed by ERT to complement the data analysis described in the previous sections. Like data analysis, photochemical modeling is a tool capable of improving the understanding of factors contributing to high ozone concentrations. The primary objective of the modeling was to assess the relative contributions of local and transported pollutants to the daily maximum ozone concentrations measured at a few sites in Ventura County. The transport component is a combination of transported ozone and ozone precursors, NMHC and  $\text{NO}_x$ . The local component is the ozone formed from Ventura County NMHC and  $\text{NO}_x$  emissions. The nature of this analysis was exploratory, and the scope was limited to examining a few days with evidence of ozone transport from Los Angeles to Ventura County.

From the outset, it was recognized that any quantification of the local and transport components would apply only to the days considered (not in general) and be approximate. The sparseness of the aerometric data available for use in modeling and the uncertainties in the model limit the reliability of estimates derived from them. For example, very little upper air wind data and no speciated NMHC data are available for the September-October 1983 study period. Also, a trajectory model was selected for use in the study because the available data were viewed as insufficient to justify use of a grid model.

The model selected is the PLMSTAR model (Godden, et al. 1985) which employs the moving "wall of cells" trajectory concept to simulate transport, dispersion, and chemical reactions. The model inputs include the available wind, temperature sounding, land cover, emissions, and air quality data. The model assumes an air parcel (approximately 20 km wide by 1 km high and divided into 25-50 cells) is advected as a continuous air mass along a trajectory for periods of up to 12 hours. While this concept may be valid for certain well-developed flow situations, it is not generally valid because the atmospheric boundary layer has significant vertical wind shear. That is, air in different layers above the surface moves at different speeds and in different directions. Trajectory models cannot explicitly simulate wind shear effects and, therefore, cannot simulate complex flow situations well. Flow fields in regions like Ventura County, which have significant terrain features and land-sea surface temperature differences, are expected to be complex, especially under meteorological conditions conducive to high ozone levels. These factors are important qualifiers on the results presented in this section. The layered nature of the flow in the study region was accounted for as well as possible, within the constraints of the trajectory modeling framework, by distinguishing surface and upper air trajectories on certain days. The surface and upper air trajectories were simulated separately until the mixing depth became sufficiently deep to entrain the upper layers. From that point on, a single air mass trajectory was simulated.

### 7.1 TRAJECTORIES AND METEOROLOGICAL CONDITIONS

Several criteria were employed in selecting days and trajectories for photochemical modeling. The principal criteria were high ozone in Ventura County and evidence of significant ozone transport from Los Angeles County to

Ventura County. Numerous days in mid-September satisfied these criteria, so a secondary criteria of trajectory reliability was employed to select three days and a total of five trajectories for modeling. The trajectories are shown in Figures 7-1 through 7-5.

Trajectory #1 for September 11, 1983 involves the most complex flow of the trajectories selected. During the morning, light westerly winds in the Santa Barbara Channel transported presumably clean air toward Ventura County at the same time as easterly winds transported ozone-laden air aloft over water from the Los Angeles Basin. Evidence for the overwater transport of ozone includes easterly winds at Malibu up to 1300 hours PST and aircraft ozone observations south of Pt. Mugu showing 100-200 ppb above the surface after 1000 hours PST. Convergence and complex mixing of the easterly and westerly flows occurred offshore in midday as the sea breeze strengthened and entrained the easterly flow from aloft. The sea breeze brought pollutant-laden air onshore in the afternoon hours. The trajectory shown in Figure 7-1 is oriented to bring the air over the El Rio monitor at 1530 PST where 140 ppb of ozone was observed, the maximum in the Ventura County network on September 11. In order to model this split trajectory case, the lower and upper layers of the air parcel were used to characterize the westerly and easterly flows, respectively. These layers were allowed to mix during the hour before the trajectory reached the shoreline.

The highest ozone concentrations during September 1983 in Ventura County were observed on the 12th. Trajectories #2 and #3 were selected for simulation on this day to illustrate the overwater and overland transport mechanisms, respectively. Trajectory #2 began offshore, south of Pt. Dume with east-southeasterly flow. Based on the offshore and coastal wind data, the flow became more southerly during the mid-morning. Trajectory #2 is oriented to bring the air onshore in Ventura at 1230 PST where 150 ppb of ozone was observed for the 1200-1300 PST hour, which was the highest hourly ozone concentration observed along the coast on this day. The trajectory also passes over the Ojai station around 1340 PST where 130 ppb of ozone was observed. Vertical wind shear along this trajectory was probably much less than along the September 11th trajectory. The available data suggest the flow aloft had roughly the same direction as the surface flow into western Ventura County; however, the wind speeds aloft were probably lower than at the surface.

Trajectory #3 begins over land, near Pomona in a light east-southeasterly flow. Previous day ozone concentrations at stations east of Los Angeles were very high, up to 370 ppb (at Azusa), so the southeasterly flow aloft is expected to have high ozone concentrations above the surface layer. Wind speeds in the southeasterly flow increased to approximately 5 m/s by midday, carrying the air past Los Angeles and into the San Fernando Valley, where 190 and 280 ppb of ozone were observed at the Reseda and Rocketdyne stations at 1200 PST. Subsequent transport carried the pollutant-laden air to the Simi Valley monitor, where 230 ppb of ozone was observed at 1300 PST. Trajectory #3 is oriented to pass the Simi Valley monitor at 1330 PST and then turn sharply to the east, reflecting the strong sea breeze flow evident in the afternoon. We are fairly confident in this trajectory's representation of the flow between 1000 and 1300 PST; however,

TRAJECTORY #1

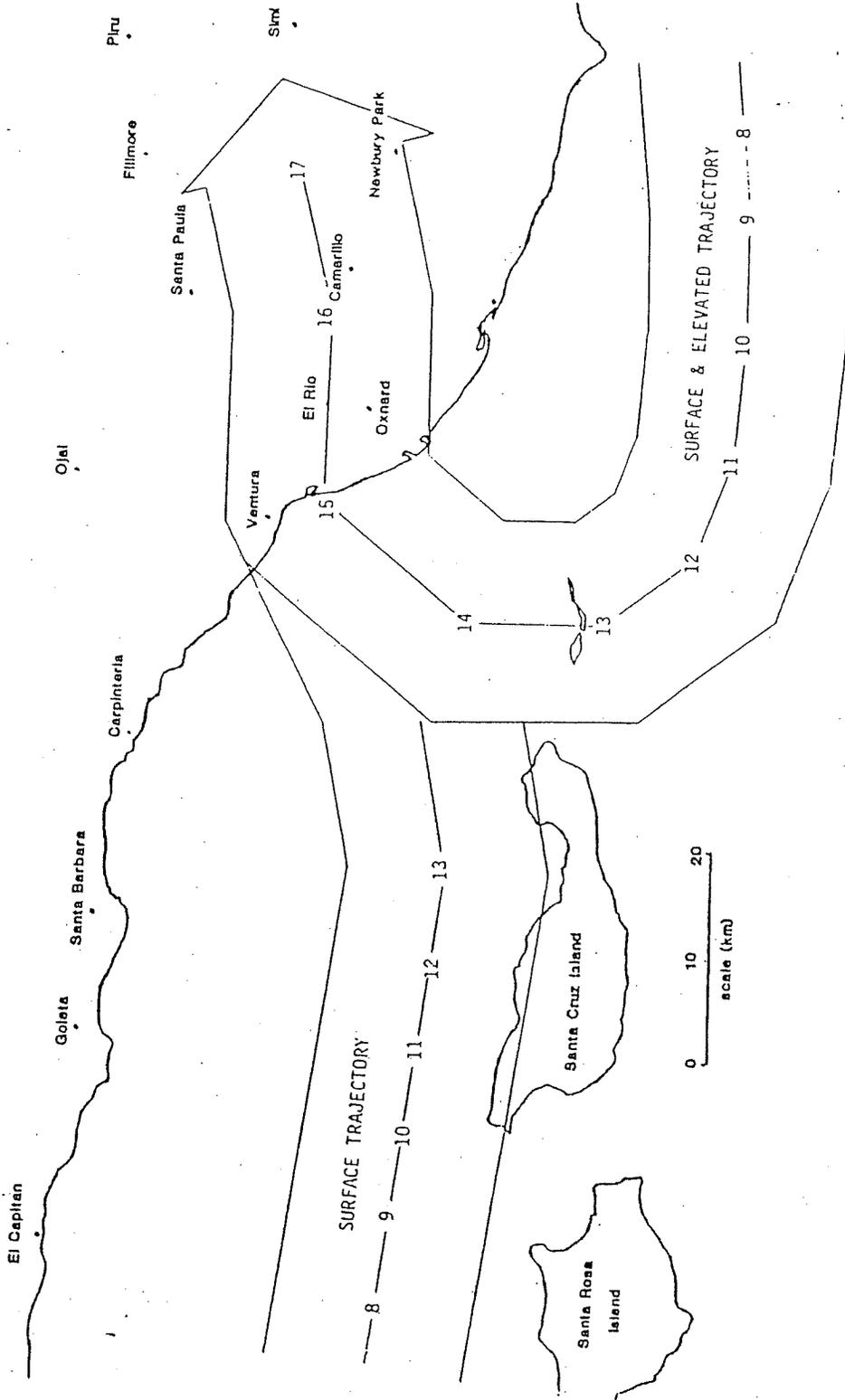


Figure 7-1. Surface and Elevated Trajectories Passing El Rio at 1530 PST on September 11, 1983.  
 (Hours shown along trajectories are PST.)

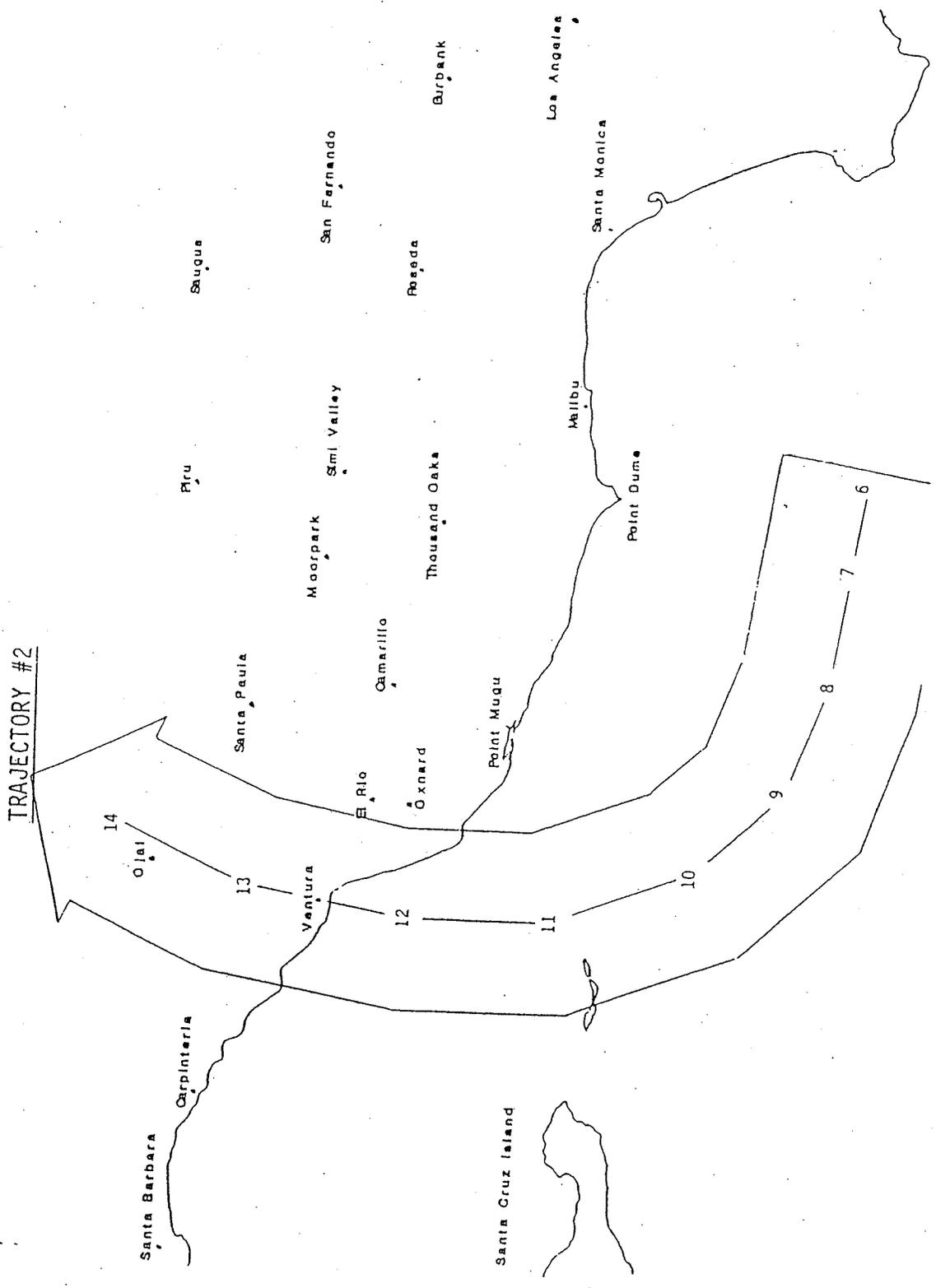


Figure 7-2. Trajectory Passing Ventura at 1230 PST on September 12, 1983.  
 (Hours shown along trajectory are PST.)

TRAJECTORY #3

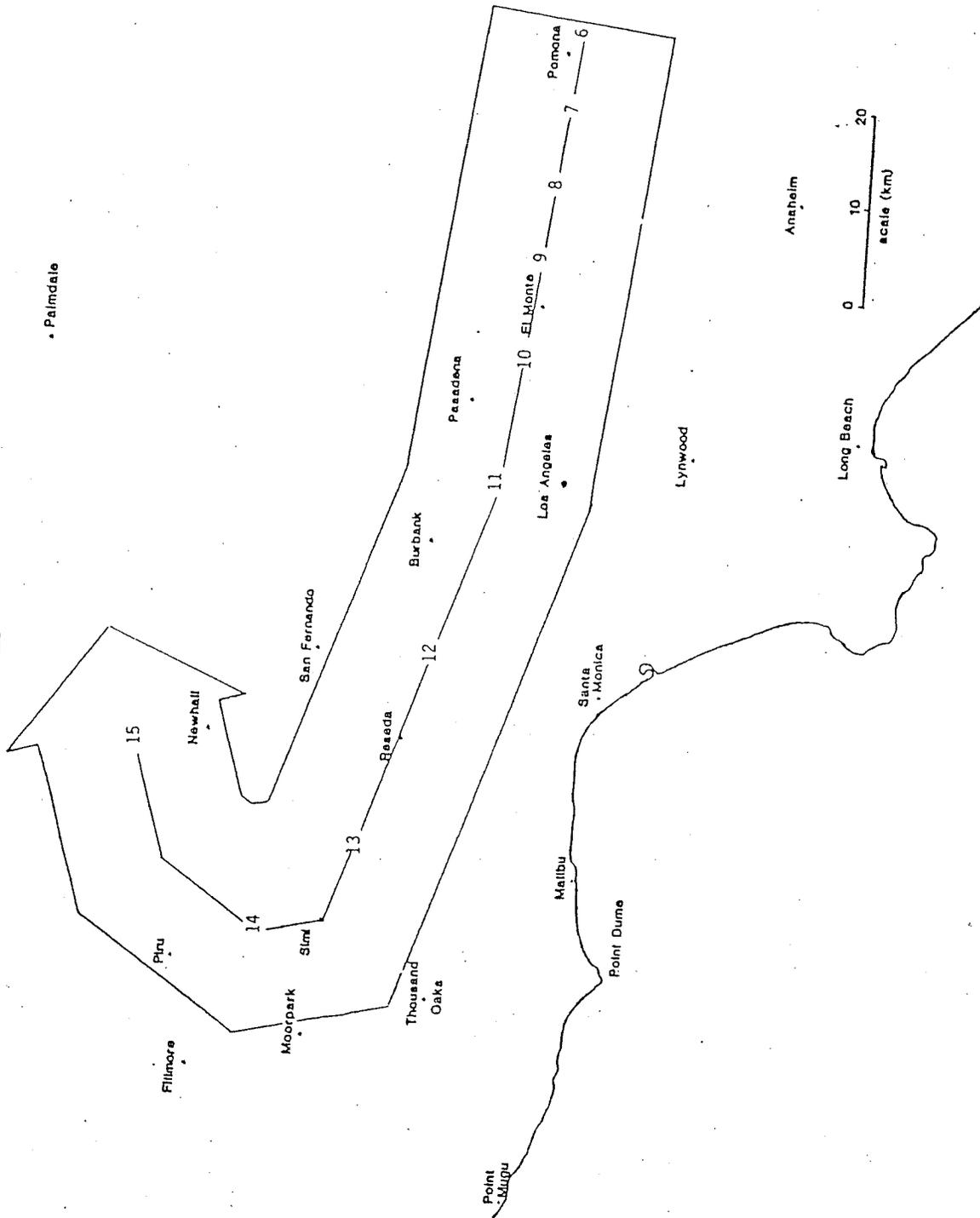


Figure 7-3. Trajectory Passing Simi Valley at 1330 PST on September 12, 1983.  
(Hours shown along trajectory are PST.)

TRAJECTORY #4

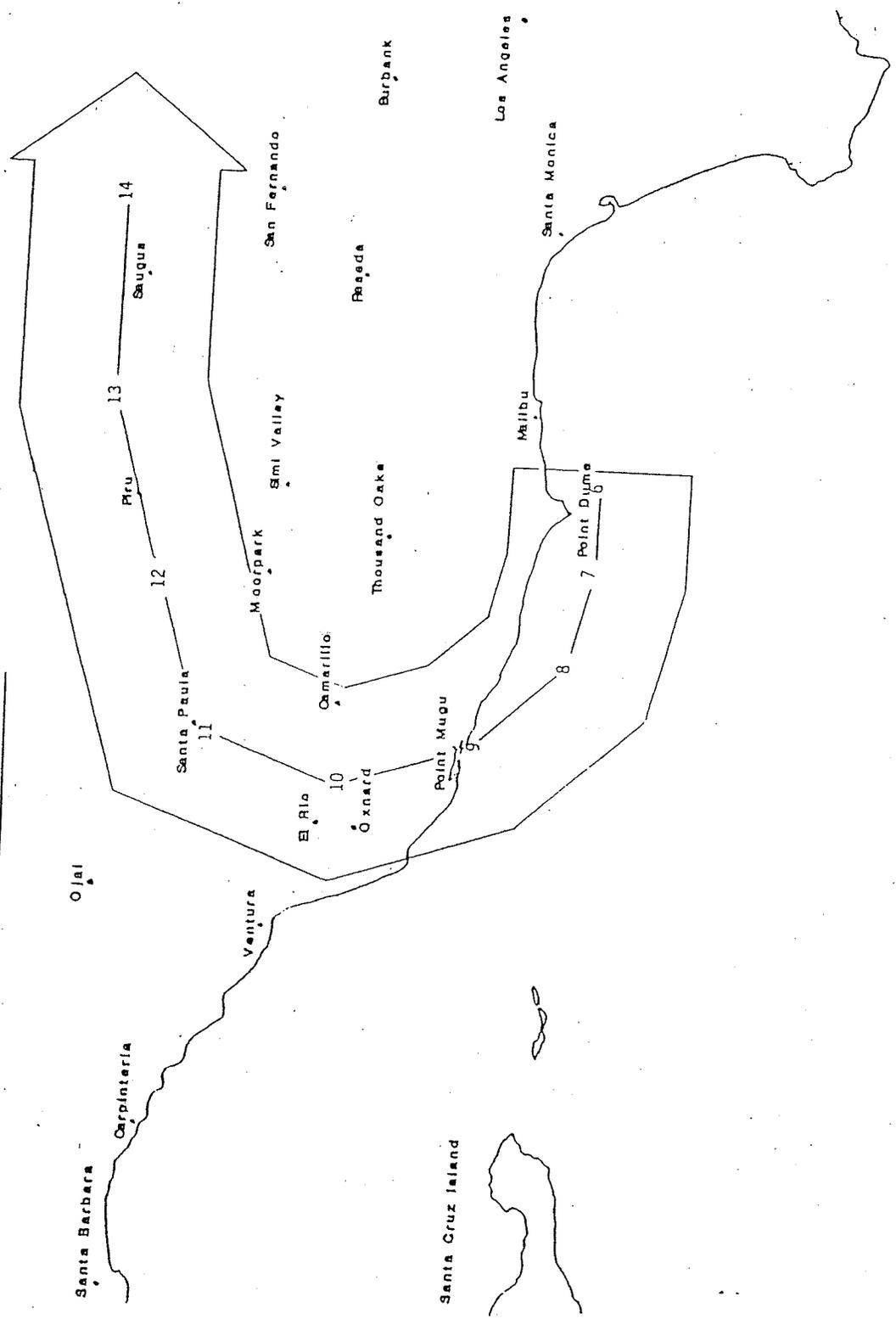


Figure 7-4. Trajectory Passing Piru at 1230 PST on September 14, 1983.  
(Hours shown along trajectory are PST.)

TRAJECTORY #5

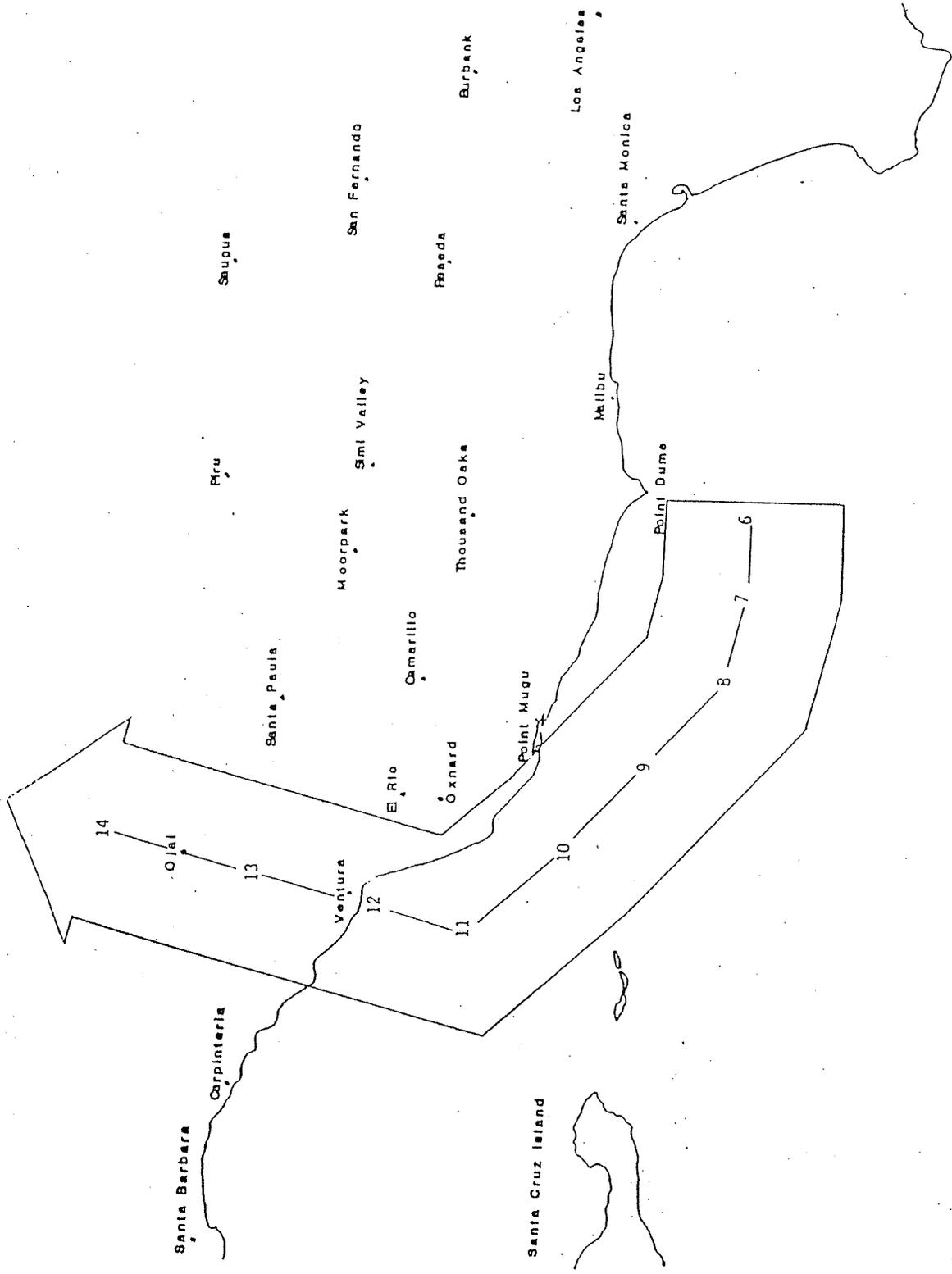


Figure 7-5. Trajectory Passing Ojai at 1330 PST on September 14, 1983.  
(Hours shown along trajectory are PST.)

between 1300 and 1400 PST (i.e., when the maximum ozone was observed), there was convergence of the sea breeze flow and flow from the San Fernando Valley, which reduces our confidence in the flow field used for the modeling after 1300 PST. Other ozone measurements along the trajectory reflect the expected trends for the sharp trajectory turn. Piru, on the outer edge of the trajectory path, observed 140 ppb of ozone at 1400 PST, presumably due to the sea breeze flow. Newhall, on the inside edge, recorded 240 ppb, presumably from much of the same air which influenced the Simi Valley monitor. It is likely, however, that the flow aloft persisted in the southeasterly direction, rather than turning inland like the surface flow. Thus, there probably was significant vertical wind shear after 1300 on this trajectory.

Trajectories #4 and #5 for September 14 illustrate cases with ozone transport over water in early morning southeast flows followed by late morning and midday sea breeze flows. Both trajectories begin south of Pt. Dume. Trajectory #4, initially closer to the coastline, traverses over Pt. Mugu (0900 PST) and Santa Paula (1100 PST) on its path to reach the Piru monitor at 1230 PST, where 140 ppb of ozone was observed. Trajectory #5 remains offshore longer than #4 and traverses Ventura at 1200 PST on its path to reach the Ojai monitor at 1330 PST, where 150 ppb of ozone was observed. Coastal fog was present (approx. 200 m thick) on this morning, so the early morning hours of both trajectories were simulated with reduced solar radiation. The winds aloft were most likely southerly or southeasterly for most of the day. Thus, vertical wind shear was possible above the mountain ridges during the later stages of trajectory #4.

Tables 7-1 through 7-5 list the hourly meteorological parameters estimated for modeling the five trajectories. Wind speed, wind direction, 50-m air temperature, atmospheric stability, and mixing height are shown. Fairly stable conditions and relatively low temperatures were used offshore. Unstable conditions and warmer temperatures were employed onshore. The mixing heights were estimated from vertical temperature profiles. All of the mixing heights were low (<600 m above ground level) during this period. The overwater mixing heights were generally 100 to 250 meters agl. The afternoon mixing heights over land were 250 to 550 meters agl.

## 7.2 AIR QUALITY INPUTS

Initial concentrations of  $O_3$ ,  $NO_x$ , and eight classes of hydrocarbons at the time and position of the trajectory start point are required for the modeling. Estimates are needed for five vertical layers up to approximately 500 m agl. Table 7-6 shows the concentrations employed for the simulations. The "surface" values were used for the lowest two layers of the air parcel (0-50 m and 50-100 m). The "aloft" values were used for the layers above 100 m. The ozone and  $NO_x$  (above 5 ppb) were roughly extrapolated from the available measurements.

Speciated NMHC measurements were not available onshore or offshore for the study period. An analysis of NMHC data collected during September 1980 in Santa Barbara and Ventura Counties was performed to derive estimates of the NMHC composition and ranges of concentrations. This analysis is

TABLE 7-1

METEOROLOGICAL CONDITIONS ALONG TRAJECTORY #1  
SEPTEMBER 11, 1983

<u>Hour (PST)</u>	<u>Wind Speed (m/s)</u>	<u>Wind Direction (Deg)</u>	<u>50-m Temperature (°C)</u>	<u>Stability (1-6)</u>	<u>Mixing Height (m agl)</u>
6	3	300	18.1	4.1	100
7	3	300	18.2	4.1	100
8	3	300	18.5	4.1	100
9	2	300	19.0	4.2	130
10	2	290	19.6	4.4	150
11	3	280	20.1	4.5	170
12	4	280	20.8	4.7	185
13	6	255	20.9	4.9	200
14	5	240	21.4	5.0	200
15	5	270	26.6	2.9	250
16	5	255	28.7	3.6	270
17	4	275	28.4	4.0	380

TABLE 7-2

METEOROLOGICAL CONDITIONS ALONG TRAJECTORY #2  
SEPTEMBER 12, 1983

Hour (PST)	Wind Speed (m/s)	Wind Direction (Deg)	50-m Temperature (°C)	Stability (1-6)	Mixing Height (m agl)
6	3	110	21.0	5.0	100
7	3	110	21.7	5.0	100
8	3	120	22.3	5.0	125
9	2.5	140	23.9	5.0	150
10	4.5	160	24.7	5.0	175
11	4.5	180	25.2	5.0	200
12	5.0	195	25.3	5.0	200
13	4.0	195	28.1	3.0	270
14	3.0	205	29.7	2.1	210
15	3.0	205	29.7	2.1	210

TABLE 7-3

METEOROLOGICAL CONDITIONS ALONG TRAJECTORY #3  
SEPTEMBER 12, 1983

Hour (PST)	Wind Speed (m/s)	Wind Direction (Deg)	50-m Temperature (°C)	Stability (1-6)	Mixing Height (m agl)
6	2.0	100	19.5	3.1	100
7	2.5	100	23.2	2.3	120
8	2.0	100	26.1	2.3	140
9	3.5	100	27.3	2.1	290
10	4.0	100	28.9	2.6	350
11	4.5	115	30.7	2.7	420
12	5.0	115	31.2	2.8	440
13	5.5	115	31.5	2.9	330
13.5	4.0	165	32.6	3.0	210
14	6.0	220	31.3	2.7	320
14.5	6.0	250	30.5	2.8	320
15.0	6.0	250	29.3	2.9	270

TABLE 7-4

METEOROLOGICAL CONDITIONS ALONG TRAJECTORY #4  
SEPTEMBER 14, 1983

<u>Hour (PST)</u>	<u>Wind Speed (m/s)</u>	<u>Wind Direction (Deg)</u>	<u>50-m Temperature (°C)</u>	<u>Stability (1-6)</u>	<u>Mixing Height (m agl)</u>
6	3	90	20.0	4.0	200
7	3	110	20.8	5.0	225
8	4	130	21.9	5.0	250
9	4	170	21.9	4.4	270
10	4	200	22.3	3.8	300
11	4	255	25.7	3.4	390
12	5	255	29.6	3.8	540
13	5	270	29.2	3.6	470
14	4	270	27.5	2.4	400
15	4	270	25.9	2.4	350

TABLE 7-5

METEOROLOGICAL CONDITIONS ALONG TRAJECTORY #5  
SEPTEMBER 14, 1983

<u>Hour (PST)</u>	<u>Wind Speed (m/s)</u>	<u>Wind Direction (Deg)</u>	<u>50-m Temperature (°C)</u>	<u>Stability (1-6)</u>	<u>Mixing Height (m agl)</u>
6	3	90	20.0	4.0	200
7	3	110	20.8	5.0	225
8	4	130	21.9	5.0	250
9	4	130	22.6	5.0	300
10	3	140	21.8	5.0	250
11	3	200	21.2	5.0	225
12	4	200	22.2	4.7	260
13	4	200	26.8	3.0	400
14	4	200	28.0	2.2	390
15	4	210	28.0	2.2	290

TABLE 7-6

## INITIAL CONCENTRATIONS (ppb)

Species	Trajectory #1		Trajectory #2		Trajectory #3		Trajectory #4		Trajectory #5	
	Surface	Aloft								
O <sub>3</sub>	60	150	50	70	50	150	80	120	80	120
NO <sup>x</sup>	5	10	20	5	25	5	10	5	10	5
NO	1	2	4	1	12.5	1	2	1	2	1
NO <sub>2</sub>	4	8	16	4	12.5	5	8	5	8	4
NMHC <sup>1</sup>	300	300	400	300	600	400	300	300	300	300
>C3 Alkanes	180	210	240	210	342	280	180	210	180	210
Ethylene	39	15	24	15	42	20	18	15	18	15
Propylene	3	0	4	0	12	0	3	0	3	0
Butenes	3	0	4	0	12	0	3	0	3	0
Toluene	12	12	20	12	42	16	15	12	15	12
Xylene	12	3	32	3	60	4	24	3	24	3
Formaldehyde	9	9	12	9	18	12	9	9	9	9
>C2 Carbonyls	6	6	8	6	12	8	6	6	6	6
NMRC	51	60	60	60	90	80	45	60	45	60

<sup>1</sup>Hydrocarbon concentrations in ppbC.

<sup>2</sup>Aldehydes excluded from NMHC total.

<sup>3</sup>Surface = 0 to 100 m; Aloft = 100-400 or 500 m.

described in Appendix C. The 1980 onshore morning data showed 600 to 900 ppbC NMHC on the average in urban locations and approximately 200-250 ppbC on the average at more remote sites like Pt. Conception and Gaviota. It was assumed that the hydrocarbons offshore would be lower in concentration than those observed onshore in 1980, and values of 300 to 400 ppbC were selected. For the Pomona start location, we assumed 600 ppbC in the surface layer. The surface layer's initial NMHC composition was estimated from the 1980 Port Hueneme data for trajectories #2, #4 and #5, from the 1980 Pt. Conception data for trajectory #1, and from the 1980 Simi Valley data for trajectory #3. The NMHC composition aloft was assumed to have lower ethylene and xylenes fractions and higher alkane fractions than the Port Hueneme data. Propylene and butene fractions aloft were set to zero because their lifetimes are fairly short in the presence of significant ozone concentrations.

The initial concentration profiles, especially those for hydrocarbon species, are uncertain. Some diagnostic adjustments to the initial concentration profiles were made to improve model performance. However, it was recognized that numerous combinations of HC, NO<sub>x</sub> and O<sub>3</sub> profiles can generate similar maximum ozone predictions and that insufficient data were available to determine which combination was correct. For example, similar onshore ozone predictions can be obtained using high initial HC and NO<sub>x</sub> with low O<sub>3</sub> aloft and using low initial HC and NO<sub>x</sub> with high O<sub>3</sub> aloft. So instead of searching for the best combination of initial values, sensitivity analysis was performed for one of the trajectories to illustrate the importance of these inputs.

### 7.3. EMISSIONS INPUT

Emission inventories compiled by CARB for 1979 were employed for the modeling. The Ventura and Los Angeles County area source inventories were spatially resolved on 2 x 2 km and 5 x 5 km grids, respectively. The area source HC and NO<sub>x</sub> inventories include stationary sources with stacks less than 30 m and the mobile sources. Point sources with significant stack heights were inventoried separately by exact location rather than by grid square. The use of 1979 emissions estimates, rather than 1983, may have overestimated the emission rates. However, the difference between 1979 and 1983 is probably within the uncertainty of the estimates. 1983 data for the power plants along the Ventura County coastline and emissions from three OCS platforms (Grace, Gilda, and Gina) were included as well.

The air parcel geometry used for these trajectories employed five 4-km wide columns (20 km total width). Emission rate schedules for each column of the air parcel were generated. The total emissions entrained along the trajectories from mobile, stationary areas, and major point sources are listed in Table 7-7. These data show that trajectory #3 entrains more than a factor of 10 more HC and NO<sub>x</sub> than the other trajectories.

TABLE 7-7

HC AND NO<sub>x</sub> EMISSIONS (kg) ENTRAINED ALONG TRAJECTORIES

<u>NO<sub>x</sub></u>	<u>Trajectory #1</u>	<u>Trajectory #2</u>	<u>Trajectory #3</u>	<u>Trajectory #4</u>	<u>Trajectory #5</u>
Mobile	483	107	5278	302	213
Stationary Area	286	192	3148	198	608
Point	38	36	271	102	161
Total	807	335	8697	602	982
 <u>HC</u>					
Mobile	475	100	5547	312	255
Stationary Area	729	321	28677	781	597
Point	3	3	41	14	18
Total	1207	424	34265	1107	870